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## A Summative Evaluation of FlightSafety International's Computer Assisted Instruction known as "Principles of Troubleshooting"

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A SUMMATIVE EVALUATION OF FLIGHTSAFETY INTERNATIONAL'S  
COMPUTER ASSISTED INSTRUCTION COURSE  
KNOWN AS  
"PRINCIPLES OF TROUBLESHOOTING"

by  
Willie Don Middlebrooks

A Thesis Submitted to the  
Office of Graduate Programs  
in Partial Fulfillment of the Requirements for the Degree of  
Master of Aeronautical Science

Embry-Riddle Aeronautical University  
Daytona Beach, Florida  
May 1995

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COMPUTER ASSISTED INSTRUCTION

KNOWN AS

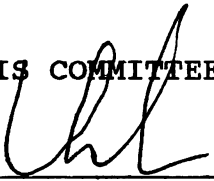
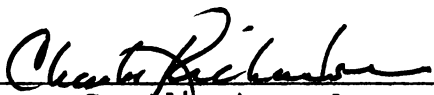
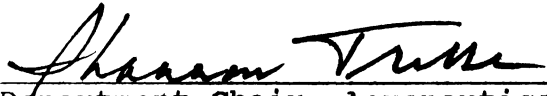
"PRINCIPLES OF TROUBLESHOOTING".

by

Willie Don Middlebrooks

This thesis was prepared under the direction of the candidate's thesis committee chairman, Dr. Diana Carl, Department of Aeronautical Science, and has been accepted in partial fulfillment of the requirements for the degree of Master of Aeronautical Science.

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### Abstract

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Title: A Summative Evaluation of FlightSafety International's Computer Assisted Instruction known as "Principles of Troubleshooting".  
Institution: Embry-Riddle Aeronautical University  
Year: 1995

The objective of this experimental research was to ascertain if cognitive skills developed by the "Principles of Troubleshooting" (POT) educational course improved aircraft fault diagnostic ability in aircraft maintenance trainees. Sixty randomly chosen Embry-Riddle Aeronautical University (ERAU) students served as control and experimental subjects with the POT course as the independent variable. Because random assignment was possible, a posttest-only control group design was used. Thirty ERAU maintenance trainees who had received basic and advanced ERAU fault diagnostic training were administered the POT course. A practical test administered to both groups using Two tailed t tests for independent means indicated improvement in fault diagnostic ability.

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## INTRODUCTION

Demographic data referred to by the Federal Aviation Administration (FAA) states that "80 to 85 percent of aviation maintenance technician school (AMTS) graduates that are employed in the aviation industry are in airline or airline-related occupations" (1992). For this reason, pre-employment training increasingly focuses on airline needs and one need is for technicians with highly developed electronic circuit fault detection or troubleshooting skills. The "replace until it works again" method is unacceptable when the simplest parts can require hours and hundreds of dollars to remove and reinstall. Most good troubleshooters are the products of pre-employment technical training and several years of post-employment experience. However, entry level technicians who possess a procedural method of thinking about troubleshooting might shorten the development period after employment. FlightSafety International (FSI), a private for profit company headquartered in New York and best known for flight simulator training, has developed a computer assisted instruction (CAI) purporting development of such aviation maintenance troubleshooting skills.

The potential benefits of FSI's CAI course would be reduced airline maintenance, reduced maintenance training time and increased airline safety. The purpose of this experimental research is to provide data regarding the relationship of the "Principles of Troubleshooting" course to the development of troubleshooting skills.

A review of instructional systems incorporating computers reveal three different types: computer assisted instruction (CAI), computer based training (CBT), and intelligent computer assisted training (ICAT). A lack of standardization in applying the names complicates communication processes. Industry consensus defining the types is needed. For purposes of this study, the following definitions will be used.

CAI is a knowledge-delivery technique using a teacher to present content and a computer to provide practice in applying theory. Perceived advantages of computer drill over teacher mediated practice with a paper and pencil formats are individualized attention in group settings and increased feedback. Computer feedback varies from low to high levels and include hints or directions.

CBT uses the computer to present content (usually written text on the screen) that the student reads and studies. Drill in the form of response questions interspersed in the text offers low level computer interaction. If the student answers incorrectly, the computer can repeat the segments of text covering the missed

questions. Some CBT programs may utilize a separate drill section and advise functions such as on screen hints or demonstrations of how to solve a problem.

ICAT is an advanced form of CBT where the computer is able to learn what and how the student is learning. It mediates in the learning process like a tutor setting next to the student. Johnson and Pieper (1991) evaluated intelligent tutoring systems as training intervention devices. They note that ICAT systems are relatively new tools and that evaluations are formative rather than summative. The scarcity of summative evaluations for ICAI makes it difficult to state with confidence what the effects are.

The FSI "Principles of Troubleshooting" course conforms to the definition of CAI because content is presented by an instructor and a computer generates electrical system simulations used in procedural drill. According to the POT training manual, "The course is a 20 hour program that will provide technicians with a method which can be used to troubleshoot complex aircraft systems" (FlightSafety International, 1989, p. 2-1). Course content focuses on deductive logic in the context of an aircraft mechanic troubleshooting electrical or electronic circuits. The computer simulations are generic electrical systems presented by digitized photos and high quality drawings. To understand relationship of components the student must reference the computer images to a pen and paper schematic.

Although only one component at a time can be viewed on the screen, the component can be viewed as it would appear in a working system. The computer generated simulation provides the ability to take voltage or resistance measurements with a screen displayed digital multimeter. A view of the instrument panel gauges pertaining to the simulated system can be selected to provide natural cues in the form of analog gauge needle movement. By working with test instrument feedback and natural cues, the student is expected to resolve faults in the simulated systems.

The course begins with an explanation of concepts FSI considers unique to POT. Chief among those concepts is the ideal that any electrical system can be viewed as a path conducting energy. In this concept, components are viewed as nodes in the path. This concept is labeled "Path of Influence". When a failure of the system occurs it can be viewed as an abnormality in the path. If multiple paths exist, the malfunctioning path is labeled "The Critical Path". A procedural rule is then established that the troubleshooter should identify this "Critical Path" and perform tests in it only. Expository instruction in these concepts is immediately reinforced with practice on the computer generated simulations. The simulations at this point of training are not electrical systems per se but are simplistic circuits of interconnected boxes designed specifically for "Critical Path" identification. Consecutive with teaching the "Paths" concepts is the teaching of the



logic symbol system. This is believed necessary because complex electrical schematics can be reduced by substituting logic symbolism for sub-circuits.

The second major event is the teaching of a generally applicable production system. A production system is the mental model including rules, principles and skills, which specify the conditional relationships between concepts (Foshay, 1989). FSI describes that production system as the following four step logic process: a) define the problem, b) find paths of influence, c) test, and d) take corrective action or repeat process (FlightSafety International, 1989, p. 5-4). Reinforcement is provided with immediate practice on various electrical systems simulated by a computer.

The course assumes prerequisite knowledge such as familiarization with electrical schematics, use of multimeters, knowledge of fault characteristics, component function and symbol identification. These prerequisites exclude the uninitiated. The initial part of the course consisting of the concepts and concept practice could be taught to persons without these prerequisites.

#### Statement of the Problem

The purpose of this study is to investigate the effects of FSI's POT course on the aircraft electronic circuit fault detection of ERAU maintenance trainees. Electronic circuit fault detection ability is defined as a cognitive skill. It enables a person to identify correctly the cause of malfunctions within systems of interrelated electrical or

electromechanical components. The effects can be observed on different performance parameters such as time on task, diagnostic methodology, number of test measurements, and accuracy. Accuracy is defined as transitioning from the initial evaluation stage to correct identification of malfunction without intervening false diagnosis.

#### Review of Related Literature

Given the nature of POT as explained in the introduction, a review of two areas of literature is indicated. One area deals with the effectiveness of computers in instructional systems. The other area examines cognitive research on the process of troubleshooting and the teaching of troubleshooting.

Ellen Bialo and Jay Sivin-Kachala (1993) reported that "Two recent analyses of over 250 studies of computer-based instruction (CBI) estimated that CBI is approximately 30 percent more effective in raising student achievement than instruction without computers" (p.14).

However, a study by Swezey, Perez, and Allen (1988) compared procedural maintenance task performance in students who were trained using traditional or low technology delivery techniques with that in students trained with computer based instruction and found effectiveness of the computer based instruction to be questionable. The purpose of their study was to contrast the effectiveness of computer based training to other training methods as measured by performance on electromechanical maintenance tasks. One

hundred and ten college undergraduates from George Mason University were divided into 11 groups of ten subjects. Each group participated in one of 11 experimental conditions controlling some independent variable based on instructional delivery. The different variables studied included the use of job performance aids, hands-on experience during training, teaching by computer based training and teaching through video tape. Results showed that the use of a job performance aid impacted the performance test to a greater extent than did other variables. They concluded that no major differences occurred between subjects trained with computer or video tape. The study indicated that important variables impacting electromechanical troubleshooting processes were separate from instructional delivery methods.

One conclusion reached from the Swezey, Perez, and Allen study is that an instructional product will not be automatically effective just because it incorporated a computer. However, there are specific examples of successful CAI efforts supporting Sivin-Kachala and Bialo.

Scandinavian Airlines integrated cockpit procedures training in the form of CAI into their DC-10 ground school training and reduced training time to first flight from 58 days to 35 days (Norwall, 1988). Masey (1985) generated data supporting an hypothesis that interactive graphics displays could teach avionics troubleshooting skills better than the actual equipment could. Crawford and Crawford (1978) conducted a study involving graphic simulation of a military

aircraft control panel. The simulated panel could dynamically respond to actions initiated by the student touching the screen. Their findings supported the hypothesis that computer based instruction could replace or at least supplement conventional training methods. The U.S. Army substituted computer based instruction for hands-on maintenance training for the HAWK missile system. Patterson (1978) conducted the study on the HAWK missile computer training and showed that maintenance task time was reduced with an improvement in performance.

The Grace Tutor, an intelligent tutoring system for COBOL, was evaluated (McKendree, Radlinski, & Atwood, 1991) three times searching for statistical data that would support the effectiveness of the program. The Grace Tutor was first tested at the State University of New York at Purchase. Eight students already enrolled in a COBOL course were selected by their teacher to use the Grace Tutor because their grades were failing. After comparing midterm to final grades, these students improved from failing to a 76% average grade. The second trial was at Metropolitan Life Insurance Company in New York City. It compared two groups of matched pairs and indicated the Grace Tutor was as effective as the traditional lecture method. The third trial was the New York Telephone Company. A pretest and posttest were administered to eight students, half in tutor and half in non-tutor groups. The Grace Tutor group showed a slight advantage, but the test numbers were small.

The evaluation of the Modified Advance Learning for Mobile subscriber equipment (MALM) by Orey, Park and Chanlin (1991) has significance to this evaluation of FSI's "Principles of Troubleshooting" course. The MALM course taught troubleshooting with the use of a computer. The MALM study examined how different methods of student/computer interaction impacted troubleshooting performance during a evaluation test. The MALM study also addressed the issues of what is troubleshooting and practitioners who attempt to fix problems without using technical manuals. MALM and FSI's "Principles of Troubleshooting" software both run on personal computers making both systems widely available. In the MALM study 60 undergraduates at the University of Georgia were divided into three groups. One group received advise during their computer-assisted training from an advise function. A second group received on screen listing of steps for correctly solving the problem but no corrective feedback. A third group had the benefit of a tutor sitting next to them. The results indicated that the third group took the least amount of time to learn. However, this group also took the longest time during testing. It is possible that trial and error impacts the problem solving learning process. Because these students had a tutor, the trial and error process was believed abridged.

Arguably, the computer does not have to be a part of a effective presentation as demonstrated by the Swezey, Perez, and Allen study. But the literature suggests that

computer-assisted instructional programs can provide advantages. The chief advantages over traditional delivery methods include student interaction such as with the touch screen incorporated in the Crawford and Crawford study and computer mediation on performance such as in the MALM study.

Computer software debugging, repairing mechanical systems, and medical diagnoses are other areas teaching the topic of troubleshooting. In these various forms, troubleshooting has been a common topic of behaviorist and cognitive research (Foshay, 1989). Mager (1982) proposed a hierarchy that is an algorithmic behavioral-based approach. This hierarchy includes the following steps: a) study the specific system and identify faults most common to that system, b) derive an algorithm for troubleshooting each common fault, c) develop instruction that teaches prerequisite parts of each algorithm, and d) teach each algorithm. Problems with this approach include inability to use an algorithm in more than one situation, time and cost in developing algorithms for each kind of fault found in each circuit that an aircraft might contain, and inability of technicians to recall algorithms.

The Swezey, Perez, and Allen study found that the use of a job performance aid assisted recall of algorithms. Their study indicated that the behaviorist approach of using algorithms in conjunction with a job aid assisted recall and produced significance increases in test performance. But

their study also indicated that the job aid was essential.

Abbey (1992) writes:

The use of an algorithm is essentially a mechanical one. When a problem is recognized as being of a certain type, and the solution method for that type of problem can be recalled and used, the task is not problem solving but an exercise. (p.11)

In the same vein, Schrader (1987) says that "problem solvers ... construct and utilize their own algorithms" (p. 518). The implication is that the behaviorist approach trains technicians and does not teach problem solving.

Other studies examining the cognitive processes involved in troubleshooting include Johnson (1988), Zeitz and Spoehr (1989), and Gitomer (1988). These authors examined mental models (organization of knowledge) possessed by expert problem solvers contrasted to mental models possessed by novice problem solvers. A consensus occurred that the models were significantly different and the important variable in effective problem solving. Johnson writes, "Although other factors are likely involved, the two major reasons for the experts' superior troubleshooting skills are amount of system knowledge, and the organization of that knowledge; both are developed through years of experience" (1988, p. 50).

Foshay (1989) compiled an article examining behavioral and cognitive strategies for teaching technical problem solving. In that article Foshay constructed an instructional

strategy for teaching troubleshooting built upon cognitive principles. First, teach the symbol system. The symbol system includes both terms and concepts. Secondly, teach the system desired. During this phase, descriptions of component function and relationship between components is taught. Thirdly, teach the failure modes of each component in the system. Include explanations of how the system works when it is not working. Fourth, teach algorithms for each type of component failure such as short to ground, open, component bypass short, and added resistance. Finally, teach a generalized process for troubleshooting. The desired outcome in the cognitive approach is to develop practitioners who construct their own algorithms as they work. Thus, these practitioners would be problem solvers and not merely technicians.

Research on the cognitive processes involved in troubleshooting and how to teach troubleshooting raise hope about programs trying to shorten development time. The research also leaves questions. Both behavioral and cognitive psychology offer foundations for building instructional systems on troubleshooting.

If the question is one of computer viability in the instructional process then the literature affirms the computer's place. The question in this study is the validity of a particular instructional package that incorporates a computer. Again the literature suggests that a presentation will not be automatically effective just because a computer



is involved. Effectiveness is dependent on design of the total presentation. Therefore, Has FlightSafety been successful in design of their total presentation?

Statement of the Hypothesis

A null hypothesis is stated: A quantitative measure of skills taken after completion of the "Principles of Troubleshooting" program will show no difference between participating subjects and non-participating subjects. Difference will be measured on the parameters of shorter time on task, lower number of test measurements, transitioning from initial evaluation to correct solution without intervening false diagnosis and completing total task.

## METHOD

### Subjects

The population consisted of aviation maintenance technology (AMT) students from Embry-Riddle Aeronautical University. These were students who successfully completed AMT 205, which is the airframe electrical systems course. Since this course is usually the eighth out of 20 AMT courses the student attends, the population was those students in the remaining 12 courses. With two classes per course and an average of 20 students per class, the population was 480 students. The population had the same aircraft maintenance experience which is to say, limited to ERAU training.

Volunteers participating in a study, according to Cochran (1983) might do so because they already know about the subject. This bias was controlled by random selection of subjects from the population. Eight of the 24 classes possible were selected by a random number table. A coin toss decided the four classes from which experimental subjects were selected. Those classes not selected to provide experimental subjects formed the control group population. From each group of four classes (about 80 students total) 30 students were chosen by random number table and asked to participate.

### Instrument

Gay (1987) discussed the need and methods for testing validity and reliability of self-developed test instruments. Gay advocated the use of standardized instruments administered by experienced researchers. But a review of Mental Measurements Yearbook did not yield a standardized instrument that suited this particular experiment. The reason is that a measure of skills performance was desired rather than an assessment of cognitive changes. However, the ERAU AMT department possesses an electrical system mock-up that has been used for more than ten years. The mock-up is used to train students in the use of multimeters and preliminary aspects of electrical system troubleshooting. Instructors who utilize the mock-up have through the years continuously compared student performance against written performance objectives. Therefore, the mock-up has undergone some reliability and validity assessment.

Physically, the mock-up is a four foot by eight foot base of sheet metal (Figure 1) standing on end. On it are a variety of electrical components representing four different electrical circuits. Each circuit corresponds in function to a circuit found in most aircraft. Each contains control devices allowing the operator to insert three types of faults: bypass shorts, shorts to ground, and opens. These can exist in the path or within a circuit component. The artificial faults are cleverly concealed which can lead the subject to believe that the path or component tested is, in

actual fact, defective. Treatment and control group subjects were asked to diagnose a fault in each of the four circuits.

Circuit one was the rotating beacon circuit and the fault was an open in the motor. Circuit two was the wiper motor circuit and the fault was a stuck contact in relay four. Circuit three was the navigation light circuit and the fault was an open in the dimming resistor. Circuit four was the landing light/taxi light combination circuit and the fault was an open in wire L34A14. Appendix B contains schematics for each circuit.

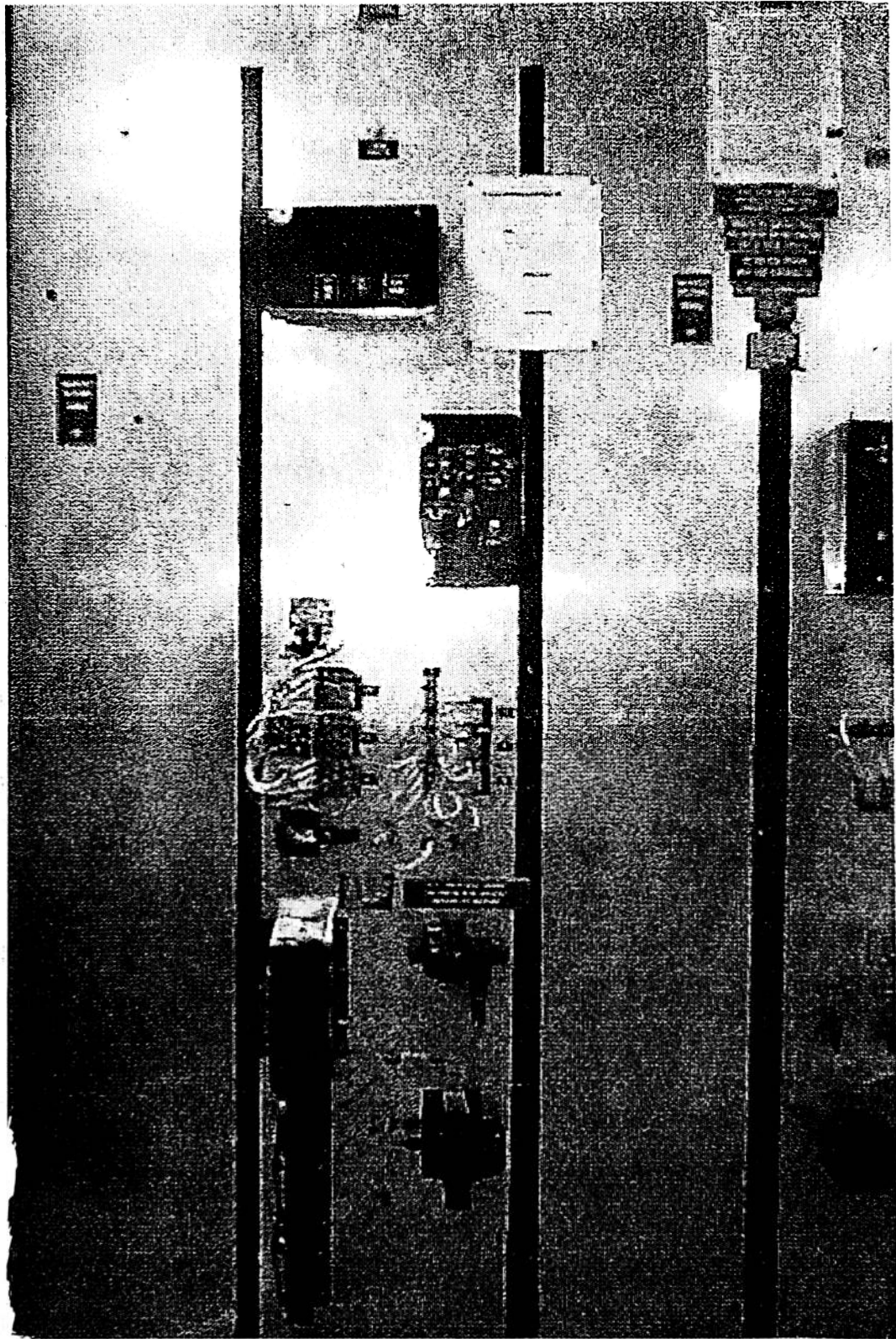


Figure 1. Photograph of the electrical system mock-up.

Testing was conducted by the principal researcher and an assistant working separately with different subjects. The preliminary data was in the form of detailed notes about the subject's performance. These notes were analyzed at a place and time separate from the testing site and time. No attempt at evaluation was made during actual testing. So that consistency of note taking could be created three practice runs (pilot study) were conducted by the principal researcher and assistant working together and discussing observations. These allowed the researcher and assistant to develop the same observation techniques and to select the specific faults that presented the greatest challenge to the subjects.

### Design

This study used the experimental post-test only control group design. The combination of random assignment, a control group, lack of a pretest and short duration of treatment eliminated most threats to external and internal validity of the research. Mortality was not a problem, due to the short duration of the treatment (20 hours). The independent variable was FlightSafety International's "Principles of Troubleshooting" course. The dependent variable was change in troubleshooting ability as measured by the reference test given to both groups. This reference test was the requirement to diagnose one fault each in the four electrical circuits contained within the electrical

mock-up described in the instruments section. Table 1 shows the experimental design.

Table 1

Experimental Design of Groups

Group	Assignment	Number	Treatment	Post-test
treatment	random	30	P.O.T. course plus the standard basic	four fault mock-up
control	random	30	standard basic	four fault mock-up

Procedures

For purposes of familiarization and first contact, FSI provided pro bono training for two ERAU faculty members (the principal researcher and assistant researcher) during the fall of 1992 at facilities at West Palm Beach, Florida. The course duration was two and 1/2 days for a total of 20 hours and it was instructor presented with the computer providing drill. The actual lecture was about five hours of the total and focused on teaching the generic troubleshooting procedure developed by FSI.

During the first week of January 1993, a work statement (Appendix C) was forwarded to FlightSafety International. The letter specified responsibilities and benefits to both ERAU and FlightSafety International. Chief among

responsibilities of FlightSafety International was the obligation to conduct four classes on the campus of ERAU. Those classes constituted treatment to the experimental group. The dates of March 15 through March 19, and March 22 through March 26, 1993 were set for these classes.

During the third week of Spring A term of 1993 the AMT classes in session were analyzed for inclusion into the experiment population. ERAU's maintenance program divides the standard college semester into two equal terms labeled "A" and "B" term. Each term is of 36 days duration. A strategy developed during this analyzing phase. Because most mechanics beginning employment for the airlines have the same basic exposure to troubleshooting as a certain group of ERAU students, a decision was made to identify those students and use them as the population. Those students were identified as the ones who had successfully passed AMT 205 which is the airframe electrical systems class. The airframe electrical systems class was thus identified as the "standard basic" training in electrical troubleshooting.

The acceptable 1993 Spring "A" term classes in session were identified by examining all AMT Spring rosters. The name of each class was written on a numbered three by five index card. Using a random number table eight classes were chosen. By the flip of a coin, four classes were chosen to provide the treatment subjects. A roster of the four classes was studied and some students excluded if they had not successfully completed AMT 205. Using a random number table



30 students were selected and approached about participating. Using a similar process the control subjects were chosen.

Roethlisberger and Dickson (1939) conducted light level effect on worker production and produced results not from treatment but from knowledge of participation in an experimental study. An inference from that study to this experiment might be that participants would produce beyond their norm if they know what their role in the study truly consisted of. To control for this bias, control and treatment subjects were truthfully informed that observations recorded during the reference test were for purposes of pattern discernment but performance comparison was not revealed. Neither group had awareness of the other or awareness of participation in a more global effort. All subjects were informed that performance in the reference test did not affect school grades either adversely or beneficially.

The principal researcher and assistant researcher who attended the familiarization course administered the reference test to both groups. The principal researcher holds a B.S. degree in aviation maintenance management and has 23 years teaching experience. The assistant researcher holds a Master's in Engineering and has about three years of teaching experience. Both are licensed airframe and powerplant mechanics. The instructor who taught the POT class is an employee of FSI and is one of an undisclosed

number of instructors working for FSI that normally teach the POT class.

The POT classes were taught over two weeks beginning Monday, March 15, 1993. The 30 treatment subjects were taught in groups of eight, six, eight, and eight. The first group attended class from 0800 Monday to noon, Wednesday. The second group attended class from 1300 hours Wednesday to 1700 hours Friday. A third and fourth class repeated the sequence during the second week. These treatment group students were excused from their regular classes while attending the POT class. The hours missed in the regular classes had to be made up by prior arrangement with the affected AMT instructors. The control group students continued attending their regular classes without any special changes taking place in their schedules. The treatment subjects were from different AMT classes than the control subjects and neither group was aware of a comparison process taking place.

During the last week of the 1993, Spring "A" term, the researchers conducted trial reference tests as a reaction to Rosenthal (1966) who researched the skewing of test results by experimenters. These tests consisted of both researchers jointly observing volunteer students conduct troubleshooting problems on the electrical systems mock-up that would later be used as the control and treatment group post-test. These tests also allowed the researchers to develop a format for conducting the post-test and develop uniform observation

practices and terminology to use in recording observations. The format consisted of: a) handing each test taker a written set of instructions (appendix A) that would explain test expectations, b) allowing each test taker to operate the system without faults, c) insertion of one fault into each of the four circuits by the researcher, d) the test taker conducting a troubleshooting process until each fault was identified, e) and the researcher recording observations of subject activity as written notes. Specific activity identified for recording included; time started, time spent on each circuit, time finished, number of measurements to solve each circuit, and number of false diagnoses. A decision was reached during the trial reference testing that extraneous notes would be kept about test taker movements such as "subject studied schematic", or "subject measured voltage at connection of wire E40B10 and terminal strip one". Experimentation during the reference tests also yielded the selection of one fault within each of the four circuits that seemed most practical to use.

Administration of the post-test to the control group subjects began the second week of the 1993, Spring "B" term and continued at the rate of two subjects per day until the 30 were completed. Testing of the treatment group began March 20 after completion of the POT course by the first two treatment groups and concluded March 30.

Data from the written observation notes were processed into raw scores and statistically evaluated using two tailed

t tests for independent means as described in the statistics text written by Elzey (1971). Such t tests should indicate if differences between groups are due to sampling error or if treatment caused the existence of two different populations. Probability level was set at 0.05 for rejection of the null hypothesis. The t test was chosen because it allows for discrimination between independent and nonindependent means and specifically applies to two groups with one independent variable. Data was organized using a five by two factorial design as depicted in table 2, "Summary of Results."

## ANALYSIS

A two tailed t test for independent means was used to determine whether there was a significant difference between the means of the two groups on five criteria: average time to complete the four circuits, average number of measurements taken to complete all solutions, percentage of first diagnoses being correct, percentage of the four circuits solved, and number of subjects completing all four circuits. This statistical technique was utilized because the requirement of random assignment to groups for a parametric test was met. Table 2 summarizes the means of the five criteria for the two groups.

Table 2

### Summary of Results

Criteria	Experimental group	Control group
average time to complete four circuits	33.6 minutes	43.37 minutes
average number of measurements taken to complete all solutions	10	14
percentage of first diagnoses being correct	91.666 percent	78.3333 percent
percentage of the four circuits solved	98.333 percent	88.333 percent
percentage of subjects completing all four circuits	93.333 percent	73.333 percent

Table 3 illustrates the variance between the time means to complete the reference test. The N for each group is 30. The probability level of .05 for 40 degrees of freedom is 2.021 and for 60 degrees of freedom is 2.000. The t ratio was computed to be 2.9547068 at 58 degrees of freedom. Therefore on the criterion of time to complete four circuits, the null hypothesis is rejected. For individual scores refer to Appendix D.

Table 3

Analysis of time in minutes

source of variation	ss	Sum X	Sum X <sup>2</sup>	t at 58 df	P at 40 df
Treatment group	4,607.2	1,008	38,476	2.95	2.02
Control group	4,904.97	1,301	61,325		

Table 4 illustrates variance between the number of measurement means. The N for each group is 30. The probability level of .05 for 40 degrees of freedom is 2.021 and for 60 degrees of freedom is 2.000. The t ratio was computed to be 4.154 at 58 degrees of freedom. Therefore on the criterion of number of measurements to complete the four circuits, the null hypothesis is rejected. For individual scores refer to Appendix D.

Table 4

Analysis of Number of Measurements

source of variation	ss	Sum X	Sum X <sup>2</sup>	t at 58 df	P at 40 df
Treatment group	282	300	3,282	4.15	2.02
Control group	538.97	421	6,447		

Table 5 illustrates variance between the means of percentages of first diagnoses being correct. The N for each group is 30. The probability level of .05 for 40 degrees of freedom is 2.021 and for 60 degrees of freedom is 2.000. The t ratio was computed to be 38.58. Therefore on the criterion of percentage of first diagnoses being correct, the null hypothesis is rejected. For individual scores refer to Appendix D.

Table 5

Percentage of First Diagnoses Being Correct

source of variation	ss	Sum X	Sum X <sup>2</sup>	t at 58 df	P at 40 df
Treatment group	0.54	27.5	25.75	38.58	2.02
Control group	2.47	23.5	20.88		

Table 6 illustrates the variance between the means on the percentage of the four faults solved criterion. The N for each group is 30. The probability level of .05 for 40 degrees of freedom is 2.021 and for 60 degrees of freedom is 2.000. The t ratio was computed to be 2.3447 at 58 degrees of freedom. Therefore on the criterion of percentage of first diagnoses being correct, the null hypothesis is rejected. For individual scores refer to Appendix D.

Table 6

Percentage of the Four Faults Solved

source of variation	ss	Sum X	Sum X <sup>2</sup>	t at 58 df	P at 40 df
treatment group	0.12	29.5	29.13	2.34	2.02
Control group	1.47	26.5	24.88		

Table 7 illustrates variance between the means on the number of subjects completing all four faults. The N for each group is 30. The probability level of .05 for 40 degrees of freedom is 2.021 and for 60 degrees of freedom is 2.000. The t ratio computed to be 2.1213 at 58 degrees of freedom. Therefore on the criterion of number of subjects completing all four faults, the null hypothesis is rejected. For individual scores refer to Appendix D.



Table 7

Number of Subjects Completing All Four Faults

source of variation	ss	Sum X	Sum X <sup>2</sup>	t at 58 df	P at 40 df
Treatment group	1.87	28	28	2.12	2.02
Control group	5.87	22	22		

In each instance the t ratio indicated that the means varied by more than what sampling error or chance would have created. Therefore the null hypothesis that no difference would occur between participants in the FlightSafety course and non participants on each criterion is rejected in favor of the "Principles of Troubleshooting" course.

## CONCLUSIONS

The treatment group completed the testing in 77.5% of the time needed by the control group. It gathered 71.4% of the number of measurements and were more accurate in their first diagnoses. Over ninety-one percent of the treatment group were correct in their first diagnoses compared to 78.333% for the control group. The increased speed, reduced number of measurements and increased accuracy in diagnoses suggests that a method for troubleshooting was acquired. The benefit to an employer would be more maintenance accomplished in a given amount of time with less likelihood that non-defective parts would be replaced.

The control group correctly solved 88.333% of all four circuits as compared to 98.333% for the treatment group. This means that the control group left almost 22% of their work undone as compared to less than 2% left undone by the treatment group. Almost 27% of the control group were not able to correctly diagnose all four circuits compared to less than 7% of the treatment group who did not. It would suggest that maintenance managers could expect graduates of the POT course to accomplish more of their work with less supervision and outside help.

These results are consistent with those of Norwall (1988), Masey (1985), and Patterson (1987) regarding the

ability of computer assisted instruction to reduce training time, improve skills, and do so less expensively than traditional training methods.

Two questions about threats to the validity of this research are left unanswered. Did the short time space between the treatment and testing of the treatment subjects cause the treatment subjects to perform better? Did the treatment subjects out perform the control group just because they had received some sort of treatment (the Hawthorne effect)? The first threat could have been eliminated by waiting a month before testing the treatment group. An attempt to control the second threat was made by not revealing the existence of a comparison process in the experiment. Without argument, this would not preclude the treatment group from excelling because they had received special training. A better method would be counterbalancing the treatment group training with a type of special training for the control group.

The MALM study indicated that computer advice during learning impacted test results positively. Since the computer drill portion of the POT course offers no such advice function a question is created. Would such an advice function enhance future training? Also, the third group in the MALM study used a tutor during the computer practice portion. This group completed the training in the least amount of time but required more time during the performance evaluation. The FSI instructor provides a similar service by

giving a limited amount of mediation during the computer drills. Mediation such as explaining component relationship within the electrical schematic and encouraging the student to use the FSI "Four Step Process". Could an advice function be incorporated in the computer simulation that replaces the instructor?

Was a process for troubleshooting really learned by participants in the POT course or did the participants merely use the computer simulations to practice already ingrained strategies for troubleshooting? Because pre-testing and post-testing for cognitive strategies was not conducted it is difficult to evaluate that question.

The POT instructional design corresponds to some of the recommendations by Foshay for teaching troubleshooting. The POT instructor begins by teaching concepts and symbols believed to be part of a production system for effective troubleshooting. The POT instructor explains the particular system under study and causal relationships between components. The instructor further explains how the system works when it doesn't work. The last stage is the teaching of the generalized production system known as the "Four Step Process".

A subjective opinion is that some sort of inductive modeling process about troubleshooting was either practiced or acquired during the POT course. Inductive modeling is the discovery method of learning through practice. Whether the performance difference is due to a refinement of existing

strategies or the acquiring of a new strategy is not known and may not be important. The numbers suggest changes of some sort. Of particular interest is the percentage of first diagnoses being correct. The treatment group recorded almost ninety-two percent correct compared with about seventy-eight percent for the control group. A change in cognitive processes is at least suggested.

## RECOMMENDATIONS

Recommendations for further research include measuring changes in cognitive processes using the P.O.T. course as the independent variable. Ascertaining if the "Four Step Process" is internalized during training is a second recommendation.

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## APPENDIX A

### WRITTEN INSTRUCTIONS FOR THE FOUR FAULT MOCK-UP TEST

This board contains 4 (four) different electrical circuits.

Each circuit contains 1 (one) fault.

Please locate the fault and tell me which wire or component needs replacing.

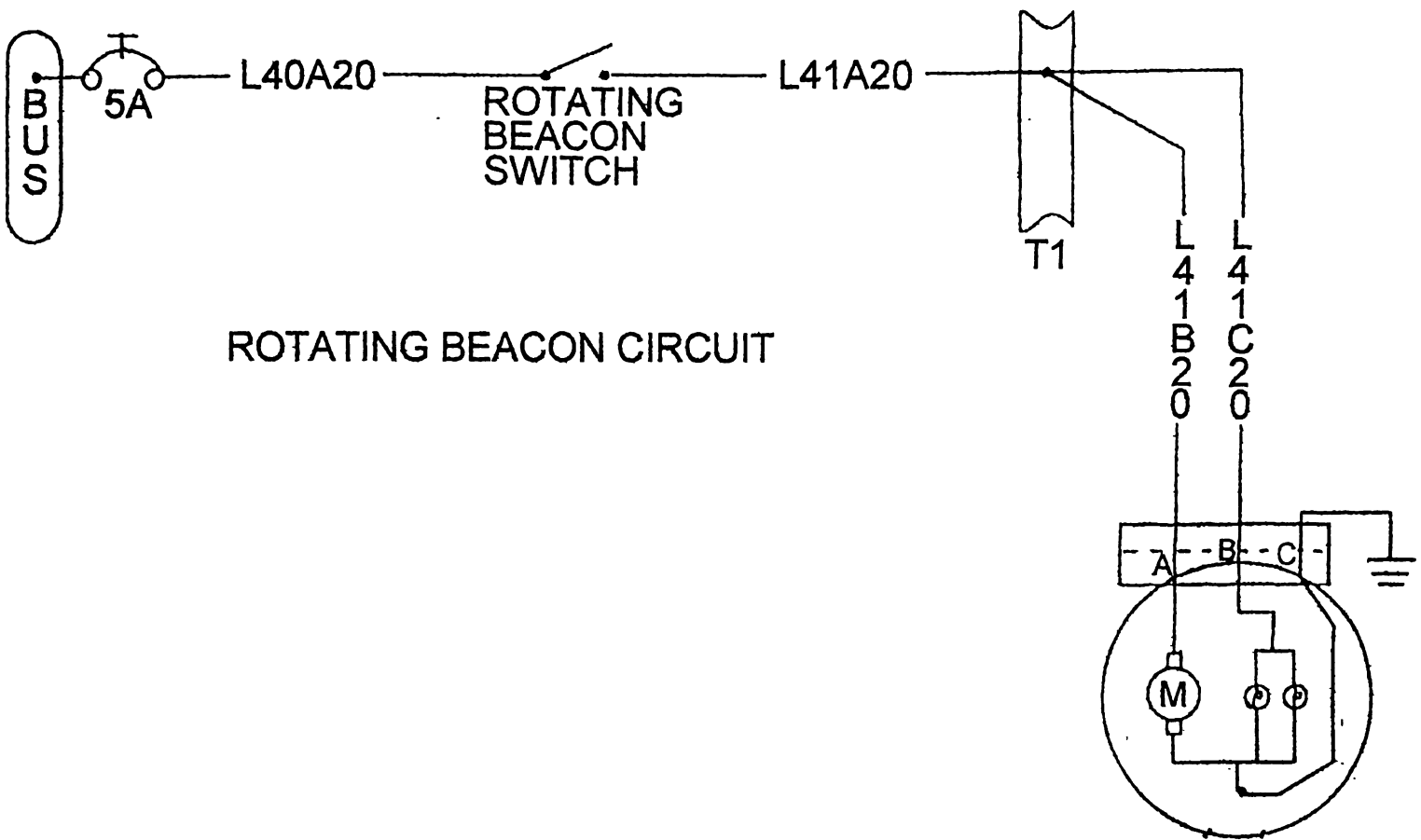
As you work, please tell me what you are doing, such as, "I am measuring the voltage where wire L20B16 connects to the switch".

Thank You

APPENDIX B

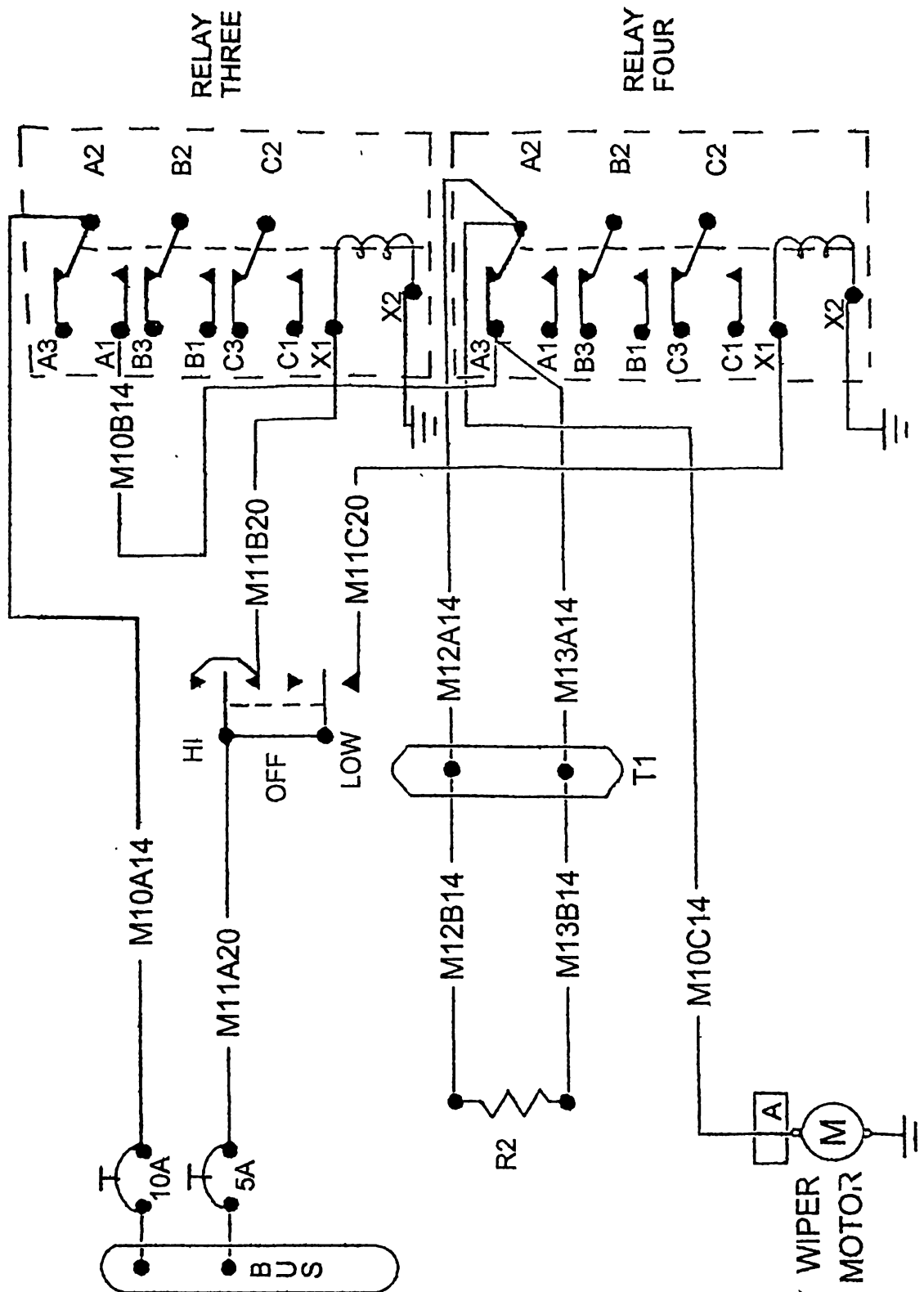
FOUR DIAGRAMS USED IN FOUR FAULT MOCK-UP TEST

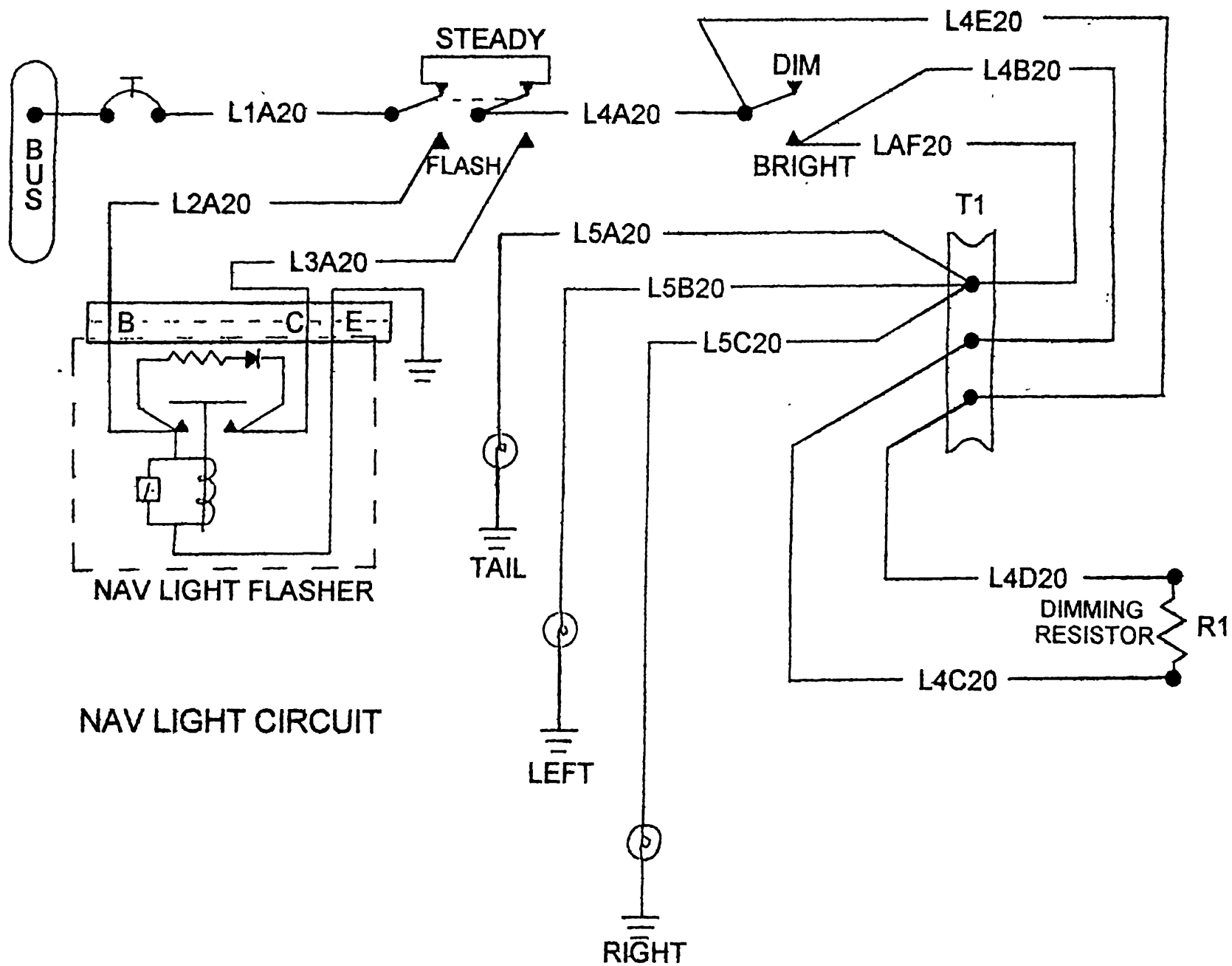
The rotating beacon;



ROTATING BEACON CIRCUIT

## Motor Circuit;

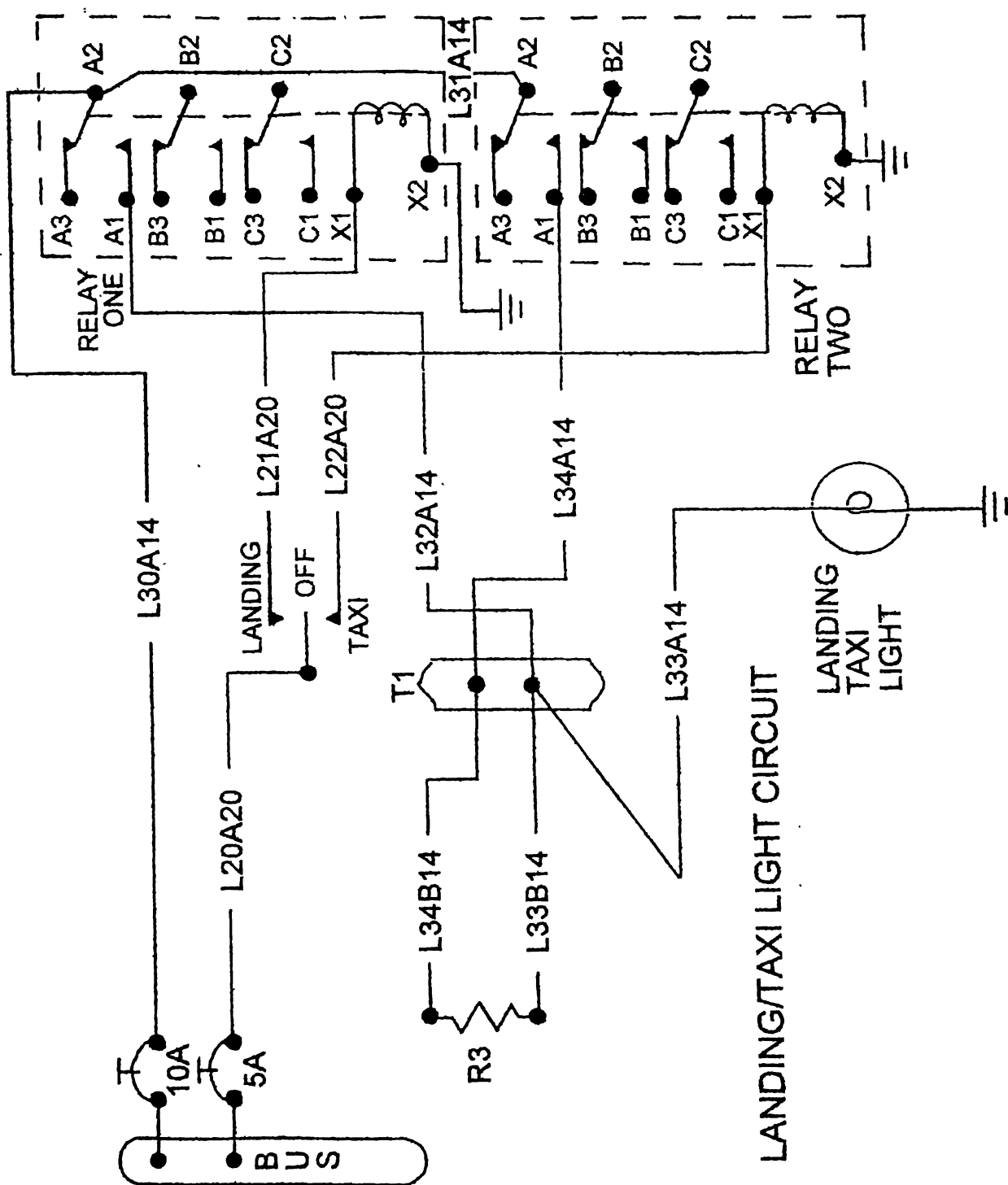




Navigation Lights;



## Landing / Taxi Light Circuit;



APPENDIX C  
WORK STATEMENT FOR  
"PRINCIPLES OF TROUBLESHOOTING" COURSE EVALUATION

Embry-Riddle Aeronautical University agrees to research the effectiveness of FlightSafety International's (FSI) "Principles of Troubleshooting" course. Part of the research project will be testing for knowledge gained. The testing method will consist of administering comparison tests to research subjects. Research subjects will be analyzed according to aviation maintenance experience, and training or formal schooling. Research subjects will be solicited by and will be under a contractual agreement with ERAU. The comparison test administered to the control group and the experimental group will be the same and consists of hands-on troubleshooting of electrical or hydraulic mock-ups. Research testing will be conducted separately from testing conducted by FSI as part of the "Principles of Troubleshooting" course. FSI will receive the results of the evaluation not later than the last day of May, 1993.

ERAU retains the right to use the results of the research project, with concurrence of FSI. FSI reserves the right to publish or suppress the results of the course evaluation. FSI will provide Embry-Riddle Aeronautical University with one set of computer software and one set of related manuals comprising the "Principles of Troubleshooting" course. The software will not be copy protected nor time dated. ERAU cannot sell the "Principles of Troubleshooting" software or conduct stand alone courses. ERAU agrees to abide by the terms set forth in the SOFTWARE LICENSE/LEASE AGREEMENT. FSI acknowledges that ERAU may incorporate the "Principles of Troubleshooting" course into ERAU's aviation maintenance program.

FlightSafety International will conduct four "Principles of Troubleshooting" courses during the weeks of March 15-22, 1993 in Daytona Beach, Florida for the purpose of this research project. ERAU will provide classroom space either on its Daytona Beach campus or in space currently leased from General Electric in Daytona Beach, Florida. ERAU will provide a chalkboard, overhead projector, 35mm projector, movie screen, and tables for the students. FSI will provide the computers, software, related manuals, teaching materials, and instructor.

The four courses will be conducted in accordance with normal procedure. Time allotted will be 20 hours per course and contained within two and one-half days each. Each course will contain six to eight research subjects.

Upon successful completion of the course, The research subjects will be provided whatever standard documents of achievement that FSI normally issues.

APPENDIX D  
SUMMARY OF TEST RESULTS

## Analysis of Time in Minutes

Subject	Experimental group	Control group
1	40	38
2	32	37
3	19	44
4	27	45
5	19	60
6	27	40
7	48	42
8	26	38
9	40	56
10	32	68
11	21	38
12	21	25
13	22	66
14	28	24
15	44	35
16	32	61
17	20	49
18	21	51
19	30	19
20	61	41
21	66	20
22	56	38
23	39	36
24	34	47
25	16	27
26	36	57
27	34	54
28	43	58
29	41	43
30	33	44

## Analysis of number of measurements

Subject	Experimental	Control
1	7	12
2	9	11
3	9	15
4	10	22
5	6	19
6	11	9
7	13	12
8	8	24
9	13	18
10	13	12
11	8	16
12	7	9
13	8	19
14	5	9
15	9	13
16	10	14
17	6	21
18	7	15
19	9	12
20	9	20
21	18	8
22	12	13
23	15	17
24	13	13
25	6	9
26	13	12
27	11	8
28	15	12
29	10	13
30	10	14

Percentage of first diagnoses being correct		
Subject	Experimental	Control
1	100	100
2	100	100
3	100	100
4	75	50
5	100	75
6	100	100
7	75	100
8	100	100
9	75	100
10	100	25
11	75	100
12	100	100
13	100	75
14	100	100
15	100	75
16	100	50
17	100	25
18	100	25
19	75	100
20	75	50
21	75	75
22	100	100
23	75	0
24	100	75
25	100	75
26	100	100
27	100	100
28	50	100
29	100	100
30	100	75

## Percentage of the four faults solved

Subject	Experimental	Control
1	100	100
2	100	100
3	100	100
4	100	100
5	100	75
6	100	100
7	75	100
8	100	100
9	100	100
10	100	50
11	100	100
12	100	100
13	100	100
14	100	75
15	100	75
16	100	75
17	100	25
18	100	25
19	100	100
20	100	50
21	75	100
22	100	100
23	100	100
24	100	100
25	100	100
26	100	100
27	100	100
28	100	100
29	100	100
30	100	100



## Subjects completing all four faults

Subject	Experimental	Control
1	yes	yes
2	yes	yes
3	yes	yes
4	yes	yes
5	yes	no
6	yes	yes
7	no	yes
8	yes	yes
9	yes	yes
10	yes	no
11	yes	yes
12	yes	yes
13	yes	yes
14	yes	no
15	yes	no
16	yes	no
17	yes	no
18	yes	no
19	yes	yes
20	yes	no
21	no	yes
22	yes	yes
23	yes	yes
24	yes	yes
25	yes	yes
26	yes	yes
27	yes	yes
28	yes	yes
29	yes	yes
30	yes	yes

For tabulation a yes was converted to a binary 1 and a no was converted to a binary 0.

## APPENDIX E

### RAW DATA FOR TREATMENT SUBJECTS

CIRCUIT ONE REFERS TO THE ROTATING BEACON CIRCUIT.

CIRCUIT TWO REFERS TO THE WIPER MOTOR CIRCUIT.

CIRCUIT THREE REFERS TO THE NAV. LIGHTS CIRCUIT.

CIRCUIT FOUR REFERS TO THE LANDING / TAXI LIGHT CIRCUIT.

Subject one, Circuit one

Time in = 1014 Time out = 1016 Elapsed time = 2 minutes

Subject performed the following actions and articulated the following comments:

Operated the system.

Says, "The beacon doesn't rotate."

Removes cannon plug from beacon unit.

Checks ohms of motor pin A to pin C at unit.

Says, "Motor is open, replace it."

Subject One, Circuit Two

Time in = 1017 Time out = 1020 Elapsed time = 3 minutes

Time in = 1042 Time out = 1057 Elapsed time = 15 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "Works at low speed in both High and low settings."

Looks at schematic and traces the low speed circuit with hi-liter.

Says, "The low speed resistor is in there all the time."

Says, "I want to move on and come back to this problem later."

Time out = 1020

Returns to problem

Time in = 1042

Studies the schematic.

Traces the hi-speed circuit with hi-liter.

Operates system listening to relays click.

Studies the schematic.

Operates the system in high speed position.

Leaves on while looking at schematic.

Turns system off.

Checks ohms A3 to A2 on relay four.

Says, "Shows 6 ohms which is the resistor. Should be about zero ohms."

Says, "Replace relay 4."

Subject One, Circuit Three

Time in = 1020 Time out = 1030 Elapsed time = 10 minutes

Subject performed the following actions and articulated the following comments:

Operated the system.

Says, "No dim lights."

Studies the schematic.

Traces the dim circuit.

Says, "I'm going to check ohms of wire L4E20 from switch to T1."

Isolates wire and indicates that he found a normal wire.

Isolates the resistor and checks ohms across it.

Indicates that the resistor showed infinity ohms.

Says, "Replace the resistor."

Subject One, Circuit Four

Time in = 1031 Time out = 1041 Elapsed time = 10 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "Landing light works O.K.."

Says, "Taxi light does not work."

Checks relay 2 by placing hand on it and turning switch to taxi position.

Studies schematic and traces with hi-liter.

Checks ohms between A2 and relay 1 to A2 and relay 2.

(wire L31A14)

Subject did isolate the wire.

Says, "Shows continuity."

Checks voltage A1 at Relay 2.

Checks voltage L34A14 and T1.

Says, "Got no volts, there."

Says, "Replace wire L34A14."

Subject Two, Circuit One

Time in = 0925 Time out = 0928 Elapsed time = 3 minutes

Subject performed the following actions and articulated the following comments:

Operated the system.

Says, "No rotation, lights O.K.."

Looks at system.

Disconnects plug at motor.

Looks at numbers on plug.

Inserts pin out into Pin A.

Switch on.

Checks voltage - Pin A at plug - shows voltage.

Says, "Replace Motor."

Subject Two , Circuit Two

Time in = 0929 Time out = 0947 Elapsed time = 18 minutes

Subject performed the following actions and articulated the following comments:

Operates system.

First in low then in high.

Says, "Hi is not hi enough. Some extra Resistance."

Studies Drawing - Spends at least 10 minutes studying drawing.

Traces Hi-speed circuit with hi-liter.

Operates system again.

Says, "My first guess is there is something is preventing the switch from A3 to A2 in relay 4 from closing."

Studies drawing some more.

Opens panel.

Says, "I want to make sure selector switch is working."

Doesn't check anything.

Says, " Relay 4 is open all the time from A3 to A2.

Says, "Replace it."

Subject Two, Circuit Three

Time in = 0948 Time out = 0952

Subject performed the following actions and articulated the following comments:

Operated the system.

Says, "Navigation lights in dim position do not work."

Studies drawing - traces with hi-liter.

Correctly identifies dim path.

Says, "Switch is on in steady and dim."

Checks voltage L4E20 at T1.

Checks voltage L4D20 at R1.

Checks voltage L4C20 at R1.

Says, "Relay is open."

Subject Two, Circuit Four

Time in = 0953 Time out - 1000 Elapsed time = 7 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "Taxi lights do not work."

Says, "Landing lights are O.K.."

Traces circuit with hi-liter.

Checked relay by listening for clicking sounds.

Checks voltage L34B14 at R3.

Checks voltage L34B14 at T1.

Checks voltage L34A14 at Relay 2.

Checks voltage A2 at Relay 2.

Checks voltage A1 at Relay 2.

Says, "Wire L34 is open."

Subject Three, Circuit One

Time in = 0853 Time out - 0857 Elapsed time = 4 minutes

Subject performed the following actions and articulated the following comments:

Operated the system.

Says, "The motor doesn't rotate."

Studies the drawing.

Searches for wire L41B20 at T1.

Moves to plug at motor.

Disconnects plug.

Inserts pin in Pin A.

Checks voltage at Pin A, wire L41B20.

Checks ohms Pin A to Pin C.

Says, "It shows eight."

Says, "Motor is open."

Subject Three, Circuit Two

Time in = 0858 Time out = 0908 Elapsed Time = 10 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says "When the switch is in high position the motor will run, but at low speed."

Says, "The low speed setting is O.K.."

Studies the drawing a long time.

Appears to be tracing the different paths using his finger tips.

Operates the system.

Says, "The switch is in high."

Checks voltage X1, Relay 4.

Says, "No volts."

Turns switch off.

Studies drawing.

Switch is off.

Removes wires from A3 and A2 of Relay 4.

Checks resistance.



Says, "Infinity."

Says, "It's open between A3 and A2."

Says, "Replace relay 4."

Subject Three, Circuit Three

Time in = 0909 Time out = 0912 Elapsed time 3 minutes

Subject performed the following actions and articulated the following comments:

Operated the system.

Says, "Navigation lights work in bright, steady and flash."

Says, "Navigation lights do not work in dim either steady and flash."

Studies drawing and traces with fingers.

Switch is on.

Checks voltage L4D20 at R1.

Says, "It's O.K.."

Checks voltage L4C20 at R1.

Says, "No volts."

Says, "Replace R1. It is open."

Subject Three, Circuit Four

Time in = 0913 Time out = 0915 Elapsed time - 2 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "The landing lights work O.K., but the taxi lights do not come on at all."

Studies the drawing.

Appears to be tracing the system with finger tips.

Puts the switch in taxi position.

Checks voltage L34B14 at R3.

Checks voltage L34A14 at A1.

Checks voltage L34B14 at T1.

Says, "L34A14 is open. Replace it."

Subject four, Circuit one

Time in = 1530 Time out = 1531 Elapsed time = 1 minute

Subject performed the following actions and articulated the following comments:

Operated the system.

Says, "The motor doesn't turn."

Disconnects the input at motor.

Checks voltage at Pin A.

Says, "It's O.K.."

Says, "Need to replace the motor."

Subject Four, Circuit Two

Time in = 1532 Time out = 1545 Time elapsed = 13 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "The motor is O.K. in low."

Says, "It runs at low speed in high position."

Studies drawing.

Looks at relays and finds the wire to X1.

Opens the panel door.

Isolates wire M11B20.

Checks ohms.

Says, "it shows O.K.."

Turns motor on in high position.

Checks voltage X1 to ground.

Turns system off.

Studies drawing some more.

Traces high mode circuit.

Traces low mode circuit.

Says, "Replace relay 4."

Subject Four, Circuit Three

Time in = 1546 Time out = 1555 Elapsed time = 9 minutes

Subject performed the following actions and articulated the following comments:

Operated the system.

Says, "No dim at all. Bright O.K.."

Studies drawing.

Traces circuit.

Correctly identifies the dim path through R1.

Isolates wire L4E20 from switch to T1.

Checks ohms.

Says, "O.K.."

No change.

Says, "Need to replace wire L4B20."

Switch in dim.

Checks voltage across R1.

Says, "Need to replace R1."

Subject Four, Circuit Four

Time in = 1556 Time out 1600 Elapsed time = 4 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "There is no taxi light."

Says, "Landing light is O.K.."

Studies drawing.

Checks voltage L31B14 at R3.

Checks voltage L33B14 at R3.

Checks voltage A2 at Relay 2.

Checks voltage A1 at Relay 2.

Checks voltage L34A14 at T1.

Says, "Replace wire L34A14."

Subject Five, Circuit One

Time in = 1429 Time out = 1430 Elapsed time = 1 minute

Subject performed the following actions and articulated the following comments:

Operated the system.

Says, "The beacon is not rotating."

Studies drawings.

Traces motor circuit.

Checks voltage Pin A to ground.

Says, "It shows voltage."

Says, "The motor is open."

Says, "Replace motor."

Subject Five, Circuit Two

Time in = 1431 Time out = 1436 Elapsed time = 5 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "The motor runs at low speed in the high position."

Studies drawing.

Traces high speed path.

Says, "Relay 4 switch between A3 and A2 stays open all the open."

Checks voltage A3 to A2 Relay 4.

Says, "Need to replace Relay 4."

Subject Five, Circuit Three

Time in = 1437 Time out = 1443 Elapsed time = 6 minutes

Subject performed the following actions and articulated the following comments:

Operated the system.

Says, "Lights are O.K. in bright."

Says, "No lights in dim."

Studies drawing.

Traces dim path.

Says, "There is an open in the path connecting the resistor and it is going to cut the path in half. I'm going to check the ohms of R."

Says, "R1 is open."

Says, "Replace it."

Subject Five, Circuit Four

Time in = 1444 Time out = 1451 Elapsed time = 7 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

"Says, "There is no taxi light."

Studies drawing a long time.

Traces taxi light circuit.

Operates system again.

Studies drawing again.

Retraces the landing light and taxi light.

Identifies path through R3 as open path.

Cuts that path in half and checks infinity of R3.

Says, "It's O.K.."

Checks voltage across Relay 2, A2 to A1.

Checks voltage across L34A14.

Says, "It shows total voltage."

Says, "Replace it."

Subject Six, Circuit One

Time in = 1444 Time out = 1446 Elapsed time = 2 minutes

Subject performed the following actions and articulated the following comments:

Operated the system.

Says, "Lights are O.K.."

Says, "Motor won't rotate."

Disconnects pin at unit.

Checks voltage at Pin A.

Says, "OK."

Checks ohms Pin A to Pin C - Infinity.

Says, "Replace motor."

Subject Six, Circuit Two

Time in = 1447 Time out = 1506 Elapsed time = 19 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "It only works on low in both positions."

Studies drawing.

Traces high circuit.

Traces low circuit.

Operates system.

Studies drawing.

Switches master on.

Switch in high position.

Checks voltage A1, Relay 3.

Says, "OK."

Checks voltage A3, Relay 4.

Says, "OK."

Checks voltage X1, Relay 4.

Says, "No, which is O.K.."

Studies drawing.

Rechecks voltage A3, Relay 4.

Says, "Replace Relay 4."

Subject Six, Circuit Three

Time in = 1507 Time out = 1510 Elapsed time = 3 minutes

Subject performed the following actions and articulated the following comments:

Operated the system.

Says, "Works on bright, steady, and flash, but does not work on dim."

Studies drawing.

Checks voltage L4E20 at T1.

Checks voltage L4D20 at R1.

Checks voltage L4C20 at R1.

Says, "R1 is open."

Subject Six, Circuit Four

Time in = 1510 Time out = 1513 Elapsed time = 3 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "Taxi light doesn't work."

Operates system while listening to relay.

Checks voltage at A1 on Relay 2.

Says, "OK."

Checks voltage L34A14 at T1.

Says, "No volts."

Says, "Need to replace L34A14."

Subject Seven, Circuit One

Time in = 0805 Time out = 0810 Elapsed time = 5 minutes

Subject performed the following actions and articulated the following comments:

Operated the system.

Says, "Lights are O.K.."

Says, "Motor doesn't rotate."



Switches on.

Checks wire L41B20 (Voltage at Pin A).

Says, "It shows voltage."

Says, "Motor is open."

Subject Seven, Circuit Two

Time in = 0810 Time out = 0835 Elapsed time = 25 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "Runs low O.K.. Runs low speed in high position."

Studies drawing a long time.

Says, "I'm going to check infinity of ground wire X2 Relay 3 to ground."

Subject changed mind and did not do above.

Operates system switch in high.

Checks voltage at A3, Relay 4.

Checks voltage at A1, Relay 3.

Checks voltage at A2, Relay 3.

Turns system off.

Studies Drawing.

Traces system.

Pass-Over - gave up.

Subject Seven, Circuit Three

Time in = 0835 Time out = 0842 Elapsed time = 7 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "Lights are O.K. in bright. Don't do nothing in dim."

Studies drawing.

Checks voltage L4E20 and T1 to ground.

Disconnected the wire to do it but reconnects the wire.

Checks voltage L4D20 at R1.

Checks voltage L4C20 at R1.

Says, "R1 is open."

Subject Seven, Circuit Four

Time in = 0843 Time out = 0854 Elapsed time = 11 minutes

Subject performed the following actions and articulated the following comments:

Operated the system.

Says "No taxi light."

Studies drawing.

Checks voltage L34B14 at R1.

Checks voltage L34B14 at T1.

Checks voltage L34A14 at A1, Relay 2.

Checks voltage X1 to ground, Relay 2.

Checks voltage X2 to ground, Relay 2.

Says, "Need to replace Relay 2." (This is not correct).

Checks voltage L34A14 at A1, Relay 2.

Says, "Replace wire L34A14."

Subject Eight, Circuit One

Time in = 1410 Time out = 1414 Elapsed time = 4 minutes

Subject performed the following actions and articulated the following comments:

Operated the system.

Says, "Doesn't rotate. Lights are O.K.."

Unscrews plug to unit.

Checks voltage Pin A.

Says, "OK."

Says, "Need to replace motor."

Subject Eight, Circuit Two

Time in = 1414 Time out = 1425 Elapsed time = 11 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "It runs in high position but at a low speed."

Studies drawing for a long time.

Switches master on taxi on.

Checks voltage A2 Relay 4.

Says, "Relay 4 is bad."

Subject Eight, Circuit Three

Time in = 1425 Time out = 1432 Elapsed time = 7 minutes

Subject performed the following actions and articulated the following comments:

Operated the system.

Says, "OK in bright."

Says, "No dim."

Studies drawings.

Looks at wires.

Looks at numbers on different wires connected to T1.

Checks voltage L4E20 at T1.

Says, "OK."

Checks voltage L42D20 at R1.

Says, "OK."

Checks voltage L4C20 at R1.

Says, "No voltage."

Says, "R1 is open."

Subject Eight, Circuit Four

Time in = 1433 Time out = 1437 Elapsed time = 4 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "Landing lights are O.K.."

Says, "Taxi lights do not work."

Checks voltage X1 at Relay 2.

Says, "Shows voltage."

Checks voltage A2 at Relay 2.

Says, "Shows voltage."

Checks voltage L34A14 at T1.

Says, "No voltage."

Says, "Replace L34A14."

Subject Nine, Circuit One

Time in = 1602 Time out = 1607 Elapsed time = 5 minutes

Subject performed the following actions and articulated the following comments:

Operated the system.

Says, "Lights are on. There's no rotation."

Studies drawings.

Traces circuit through lights using hi-liter.

Traces circuit through motor using hi-liter.

Checks ohms across L41B20.

Says, "Shows O.K.."

Says, "Replace motor."

Subject Nine, Circuit Two

Time in = 1608 Time out = 1626 Elapsed time = 18 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "Runs in low O.K.."

Says, "High runs, but at low speed."

Studies drawing.

Traces circuits.

Looks at drawing a long time.

Opens panel to access switches.

Runs system high setting.

Checks voltage across switch at M11C20 and M11A20.

Checks voltage A3 (Relay 4) to ground.

Studies drawing.

Says, "A3 to A2 is stuck open. Replace Relay 4."

Subject Nine, Circuit Three

Time in = 1626 Time out = 1435 Elapsed time = 9 minutes

Subject performed the following actions and articulated the following comments:

Operated the system.

Says, "Lights are O.K. in bright."

Says, "Lights don't work in dim either steady or flash."

Studies drawing.

Traces the dim circuit.

Checks voltage across R1.

Checks voltage L4C20 and ground.

Checks voltage across R1 again.

Studies drawing.

Says, "L4B20 is open. Need to replace it." (Not correct).

Looks at drawing.

Says, "The resistor is dropping total voltage. Replace it."

Subject Nine, Circuit Four

Time in = 1636 Time out = 1644 Elapsed time = 8 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "Landing light is O.K. but no lightes on taxi."

Studies drawing.

Traces circuits.

Master on - Switch in Taxi.

Checks voltage across R3.

Checks voltage A2 across to A2 at both relays.

Checks voltage A2 (Relay 1) to ground.

Checks voltage L33B14 at T1 to ground.

Checks voltage L34A14 at A1.

Checks voltage L34A14 at T1.

Repeats above.

Says, "L34A14 is open. Replace it."

Subject Ten, Circuit One

Time in = 0815 Time out = 0817 Elapsed time = 2 minutes

Subject performed the following actions and articulated the following comments:

Operated the system.

Says, "Motor doesn't turn."

Checks voltage wire L41B20 Pin A.

Shows voltage.

Says, "Replace motor."

Returns system to normal.

Subject Ten, Circuit Two

Time in = 0820 Time out = 0835 Elapsed time = 15 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "No high, runs low when in high."

Studies drawing.

Switch is in high - checks voltage X1 to ground R3.

Switch is in low - checks voltage X1 to ground R3.

Checks X2 (R3) to ground for ohms.

Says, "OK."

Studies circuit a long time.

Master switch off.

Checks ohms A2 to A3 (R4).

Says, "Infinity."

Says, "Replace R4."

Returns system to normal.

Subject Ten, Circuit Three

Time in = 0840 Time out = 0845 Elapsed time = 5 minutes

Subject performed the following actions and articulated the following comments:

Operated the system.

Says, "No lights in dim position."

Looks at drawing.

Master on switch steady and dim.

Checks voltage at L4E20 and T1.

Says, "OK."

Checks voltage at L4D20 and R1.

Says, "OK."

Checks voltage at L4C20 and R1.

Says, "No voltage."

Says, "R1 is open."

Returns system to normal.

Subject Ten, Circuit Four

Time in = 0845 Time out = 0855 Elapsed time = 10 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "No taxi light in taxi position."

Studies drawing.

Master on switch in taxi.

Checks voltage X1 and ground R2.

Says, "O.K.."

Switches off.

Checks ohms X2 (R2) to ground.



Switches on in taxi.

Checks voltage L33B14 and T1.

Switches on in taxi.

Checks voltage L34B14 and T1.

Checks voltage A1 (R2). Showed O.K..

Says, "Replace L34A14."

Subject 11, Circuit One

Time in = 1003 Time out = 1007 Elapsed time = 4 minutes

Subject performed the following actions and articulated the following comments:

Operated the system.

Says, "Lights are O.K.. Motor does not work."

Looks at drawing.

Checks voltage Pin A.

Says, "OK."

Says, "Replace motor."

Subject 11, Circuit Two

Time in = 1008 Time out = 1014 Elapsed time = 6 minutes

Subject performed the following actions and articulated the following comments:

Operated the system.

Says, "Motor runs low in high position."

Studies drawing for a long time.

Traces with hi-liter.

0 measurements.

Says, "Replace R4."

Subject 11, Circuit Three

Time in = 1015 Time out = 1020 Elapsed time = 5 minutes

Subject performed the following actions and articulated the following comments:

Operated the system.

Says, "No lights in dim."

Studies drawing.

Checks voltage L4E20 and T1.

Says, "O.K.."

Check voltage L4D20 and T1.

Says, "O.K.."

Checks ohms of R1.

Says, "Infinity."

Says, "Replace R1."

Subject 11, Circuit Four

Time in = 1020 Time out = 1026 Elapsed time = 6 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "No taxi light. Landing light works."

Studies drawing.

Checks voltage L22A20 and X1 on Relay 2.

Says, "O.K.."

Checks voltage L34A20 and T1.

Checks voltage across A1 and A2, Relay 2.

Says, "Replace relay. No change."

Checks voltage L34A20 at Relay 2.

Says, "Replace L34A20."

Subject 12, Circuit One

Time in = 0720 Time out = 0722 Elapsed time = 2 minutes

Subject performed the following actions and articulated the following comments:

Master on.

Operated the system.

Says, "Motor does not turn. Lights are on."

Checks ohms wire L41B20.

Says, "Shows O.K.."

Checks ohms Pin A to Pin C at unit.

Says, "Shows infinity."

Says, "Replace motor."

System returns to normal.

Subject 12, Circuit Two

Time in = 0726 Time out = 0730 Elapsed time = 4 minutes

Subject performed the following actions and articulated the following comments:

Studies drawing.

Operates the system.

Says, "It runs in low all the time."

Studies drawing.

Master is on. Switch is in high.

Checks voltage across A3 and A2.

Says, "Shows one half."

Says, "System voltage switch is open."

Says, "Replace R4."

Returns system to normal.

Subject 12, Circuit Three

Time in = 0732 Time out = 0742 Elapsed time = 10 minutes

Subject performed the following actions and articulated the following comments:

Operated the system.

Says, "No lights in the dim position."

Hi-lites the dim circuit.

Opens panel.

Checks ohms of L4E20.

Says, "O.K.."

Checks ohms of L4D20.

Says, "OK."

Checks ohms of R1.

Says, "Shows infinity."

Says, "Replace R1."

Returns system to normal.

Subject 12, Circuit Four

Time in = 0745 Time out = 0750 Elapsed time = 5 minutes

Subject performed the following actions and articulated the following comments:

Operated the system.

Says, "There's no taxi light. The landing light is O.K.."

Hi-lites critical path.

Eliminates L33B14 because it doesn't go behind board.

Checks ohms L34A14.

Says, "It shows infinity."

Says, "Need to replace L34A14."

Returns system to normal.

Subject Thirteen, Circuit One

Time in = 0907   time out = 0911   Elapsed time = 4 minutes

Subject performed the following actions and articulated the following comments:

Looks at drawing.

Operates the system.

Says, "Motor doesn't work."

Removes plug at motor.

Checks voltage at Pin A. (Wire L41B20)

Says, "O.K.."

Studies drawing.

Says, "Replace motor."

Subject Thirteen, Circuit Two

Time in = 0912   Time out = 0925   Elapsed time = 13 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "It runs in low speed when in the high position."

Studies drawing for a long time.

Says, "Switch A3 to A2 in R4 stays open all the time."

Checks ohms A3 to A2.

Says, "Infinity."

Says, "Replace R4."

Subject 13, Circuit Three

Time in = 0930   Time out = 0931   Elapsed time = 1 minute

Subject performed the following actions and articulated the following comments:

Operated the system.

Says, "No lights in the dim position."

Checks voltage wire L4E20 at T1.

Says, "O.K.."

Checks voltage wire L4D20 at R1.

Says, 'O.K.."

Checks voltage wire L4C20 at R1.

Says, "No voltage."

Says, "Repalce R1."

Subject 13, Circuit Four

Time in = 0934 Time out = 0938 Elapsed time = 4 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "The landing light works but the taxi doesn't."

Master on, taxi on.

Checks voltage X1 on R2 - System.

Checks voltage A2 and R2.

Says, "O.K.."

Checks voltage A1 and R2.

Says, "O.K.."

Checks voltage L34A14 at T1.

Says, "No."

Says, "Replace L34A14."

Subject 14, Circuit One

Time in = 1148 Time out = 1154 Elapsed time = 6 minutes

Subject performed the following actions and articulated the following comments:

Operated the system.

Says, "Beacon - no motor. Lights O.K.."

Checks ohms across L41B20.

Says, "O.K.."

Says, "Replace motor."

Subject 14, Circuit Two

Time in = 1155 Time out = 1209 Elapsed time = 14 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "Motor runs low when in high position."

Studies drawing.

Checks voltage A3 to A2.

Says, "It shows one half system."

Says, "Replace Relay 4."

Subject 14, Circuit Three

Time in = 1210 Time out = 1212 Elapsed time = 2 minutes

Subject performed the following actions and articulated the following comments:

Operated the system.

Says, "There's no light in low condition. I have a hunch it might be resistor R1."

Checks ohms of R 1.

Says, "It shows infinity."

Says, "Replace R1."

System returns to normal.

Subject 14, Circuit Four

Time in = 1214 Time out = 1220 Elapsed time = 6 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "No low (taxi) setting."

Studies drawing.

Operates system with hand on R2.

Says, "The relay is working."

Checks R3 (ohms).

Says, "O.K.."

Checks ohms L34A14.

Says, "Replace L34A14."

Subject 15, Circuit One

Time in = 1001 Time out = 1008 Elapsed time = 7 minutes

Subject performed the following actions and articulated the following comments:

Operated the system.

Says, "No rotation."

Checks ohms wire L41B20.

Says, "O.K.."

Checks voltage at L41B20 and Pin A.

Says, "O.K.."

Says, "Motor is bad."

Subject 15, Circuit Two



Time in = 1015 Time out = 1035 Elapsed time = 20 minutes

Subject performed the following actions and articulated the following comments:

Operated the system.

Says, "It runs in low in both positions."

Studies drawing a long time.

Checks ohms A3 to R4.

Says, "Infinity."

Says, "Replace relay."

Subject 15, Circuit Three

Time in = 1035 Time out = 1040 Elapsed time = 5 minutes

Subject performed the following actions and articulated the following comments:

Operated the system.

Says, "Lights don't work on dim. OK in bright."

Hi-lites critical path.

Checks voltage L4E20 and T1.

Says, "O.K.."

Checks voltage L4D20 and R1.

Says, O.K.."

Checks voltage L4C20 and R1.

Says, "No."

Says, "R1 is open. Replace it."

Subject 15, Circuit Four

Time in = 1041 Time out = 1053 Elapsed time = 12 minutes

Operates the system.

Says, "The taxi light doesn't work."

Studies drawing a long time.

Hi-lites critical path.

Checks voltage wire L34A14 and T1.

Says, "No voltage."

Checks voltage wire L34A14 and A2 of R2.

Says, "Voltage O.K.."

Checks voltage wire L34A14 and A1 of R2.

Says, "Voltage O.K.."

Says, "Wire L34A14 is open. Replace that wire."

Subject 16, Circuit One

Time in = 1609 Time out = 1614 Elapsed time = 5 minutes

Subject performed the following actions and articulated the following comments:

Operated the system.

Says, "Motor does not turn."

Studied diagram.

Checks voltage Pin A and plug.

Says, "Replace motor."

Subject 16, Circuit Two

Time in = 1615 Time out = 1626 Elapsed time = 11 minutes

Subject performed the following actions and articulated the following comments:

Operated the system.

Says, "The motor runs at low speed in the high position setting."

Traces path of influence with hi-liter.

Studies drawing a long time.

Goes to switch between A3 and A2 in R4.

Says, "I'm going to test it."

Checks resistance.

Says, "Replace Relay R4."

Subject 16, Circuit Three

Time in = 1629 Time out = 1636 Elapsed time = 7 minutes

Subject performed the following actions and articulated the following comments:

Operated the system.

Says, "It's O.K. in bright but there's no lights in dim."

Studies circuit and traces paths.

Checks voltage at T1 and wire L4B20.

Says, "No voltage."

Checks voltage at T1 and wire L4E20.

Says, "Volts are O.K.."

Checks ohms across R1.

Says, "It shows infinity."

Says, "Replace R1."

Subject 16, Circuit Four

Time in = 1637 Time out = 1646 Elapsed time = 9 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "The landing light is O.K.."

Says, "The taxi light does not work."

Studies drawing and traces system.

Checks voltage X1 on R2.

Says, "O.K.."

Checks ohms across R3.

Says, "Shows O.K.."

Checks voltage L33B14 and R3.

Says, "It shows 0 volts."

Checks voltage L34A14 and T1.

Says, "It shows 0 volts."

Checks voltage L34A14 and A1 on R2.

Says, "It shows 28 volts."

Says, "Open in wire L34A14."

Subject 17, Circuit One

Time in = 0817 Time out = 0820 Elapsed time = 3 minutes

Subject performed the following actions and articulated the following comments:

Operated the system.

Says, "The beacon doesn't rotate."

Looks briefly at the drawing.

Checks voltage at L41B20.

Says, "Shows O.K.."

Says, "Motor needs replacing."

Subject 17, Circuit Two

Time in = 0821 Time out = 0830 Elapsed time = 9 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "It has low speed. High wiper runs as though it is in low speed."

Studies drawing a long time.

Says, "Switch A3 to A2 in R4 stays open all the time."

No measurements taken.

Says, "Replace R4."

Subject 17, Circuit Three

Time in = 0835 Time out = 0839 Elapsed time = 4 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "No dim nav. lights. Everything else is O.K.."

Studies drawing.

Checks voltage L4E20 and T1.

Says, "O.K.."

Checks voltage L4D20 and R1.

Says, "O.K.."

Checks voltage across R1.

Says, "It shows open."

Says, "Replace R1."

Subject 17, Circuit Four

Time in = 0840 Time out = 0844 Elapsed time = 4 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "No taxi light. Landing light is O.K.."

Studies drawing.

Checks voltage L34A14 at A1 and R2.

Says, "O.K.."

Checks voltage L34A14 at T1.

Says, "No voltage."

Says, "Replace L34A14."

Subject 18, Circuit One

Time in = 0906 Time out = 0910 Elapsed time = 4 minutes

Subject performed the following actions and articulated the following comments:

Operated the system.

Says, "Motor doesn't turn. Lights are O.K.."

Checks ohms L41B20 from T1 to Pin A.

Says, "It shows O.K.."

Says, "Replace motor."

Subject 18, Circuit Two

Time in = 0914 Time out = 0922 Elapsed time = 8 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "It runs in low O.K.. Runs in high position but at the low speed setting."

Studies drawing.

Traces with hi-liter.

Studies a long time.

Says, "R4 is stuck open between A3 and A2."

Says, "Replace R4."

Subject 18, Circuit Three

Time in = 0924 Time out = 0927 Elapsed time = 3 minutes

Subject performed the following actions and articulated the following comments:

Operated the system.

Says, "The dim won't work. Everything else is O.K.."

Says, "There may be a problem in Resistor 1."

Checks voltage at switch and L4E20.

Says, "OK."

Checks voltage at L4E20 and T1.

Says, "O.K.."

Checks voltage across R1.

Says, "It shows open."

Says, "Replace R1."

Subject 18, Circuit Four

Time in = 0928 Time out = 0934 Elapsed time = 6 minutes

Subject performed the following actions and articulated the following comments:

Operated the system.

Says, "There is no taxi light. Landing light is O.K.."

Studies diagram.

Traces with hi-liter.

Checks voltage L34A14 at A1.

Checks voltage L34B14 and R1.

Checks voltage L34B14 and T1.

Says, "L34A14 is open."

Subject 19, Circuit One

Time in = 1658 Time out = 1704 Elapsed time = 6 minutes

Subject performed the following actions and articulated the following comments:

Operated the system.

Says, "It is not rotating."

Point A on L41B20 test for voltage.

Says, "Good."

Check continuity for the motor at Point A.

Says, "It's open in the motor."

Subject 19, Circuit Two

Time in = 1706 Time out = 1715 Elapsed time = 9 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Looks at the diagram.

Says, "It is not going into high speed."

Looks at diagram and traces it with hi-liter.

Checks continuity on Relay 4 between A2 to A3.

Says, "Replace Relay #4."

Subject 19, Circuit Three

Time in = 1719 Time out = 1725 Elapsed time = 6 minutes

Subject performed the following actions and articulated the following comments:

Operated the system.

Looks at diagram.

Says, "It does not operate on dim."

Looks at diagram again.

Checks voltage at T1, L4E20.



System Voltage.

Checks L4D20 at R1.

System Voltage.

Checks L4C20 at R1.

Says, "It's open in R1."

Says, "Replace R1."

Subject 19, Circuit Four

Time in = 1726 Time out = 1737 Elapsed time = 11 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "There's no taxi light."

Looks at diagram.

Traces diagram with hi-liter.

Checks voltage at Relay 2 at A2 L31A14.

System.

Checks voltage at A1, Relay 2.

Says, "Replace Relay 2. No change."

Says, "Check the wrong relay."

Checked voltage L34A14 at T1.

Says, "Open wire."

Subject 20, Circuit One

Time in = 1054 Time out = 1058 Elapsed time = 4 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "The motor is not working."

Looks at diagram.

Says, "The lights are on - that means there is power."

Checks L41B20 continuity between T1 and Pt. A.

Says, "The motor is bad."

Subject 20, Circuit Two

Time in = 1100 Time out = 1125 Elapsed time = 25 minutes

Subject performed the following actions and articulated the following comments:

Operated the system.

Looks at diagram and operates system.

Says, "The high position is working on low position. The low side is O.K.."

Traces diagram with hi-liter.

Says, "I don't know where to start."

Says, "I think Relay 4 is bad but I don't know where."

Checks between A2 and A3 for continuity on Relay 4.

Says, "Nothing."

Says, "Replace Relay 4."

Subject 20, Circuit Three

Time in = 1127 Time out = 1136 Elapsed time = 9 minutes

Subject performed the following actions and articulated the following comments:

Operated the system.

Says, "It's dim on nav. - lights are not working."

Looks at diagram.

Checks voltage L4E20 at T2.

22.9 System.

Says, "It is not open in L4E20."

Checks voltage L4D20 at R1.

22.9 System.

Says, "It is fine."

Checks R1 for opening.

Says, "It is open in R1."

Says, "Replace R1."

Subject 20, Circuit Four

Time in = 1137 Time out = 1200 Elapsed time = 23 minutes

Subject performed the following actions and articulated the following comments:

Operated the system.

Says, "The taxi light is not working."

Looks at diagram.

Traces diagram.

Checks L32A14 voltage in taxi position.

Says, "No voltage."

Subject measures L32A14 and switch is on taxi position.

Checks Relay between A1 and A2.

Says, "It is open."

Says, "Relay 1 is bad. No charge."

Checks L34A14 at T1.

Says, "Zero volts."

Checks Relay 2 at A1.

Says, There is voltage."

Says, "L34A14 is open."

Says, "Replace wire L34A14."

Subject 21, Circuit One

Time in = 0942 Time out = 0949 Elapsed time = 7 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "The problem is the rotating beacon is not rotating."

Looks at diagram.

Checks continuity of L41B20 between T1 and canon plug.

Says, "It is good."

Checks between Pt. A and Pt. C for continuity.

Says, "The motor is bad - needs to be replaced."

Subject 21, Circuit Two

Time in = 0950 Time out = 1012 Elapsed time = 22 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "The wipers won't switch to high position."

Looks at diagram.

Checks LM11B20 on Relay 3 (voltage) voltage on both low and high position.

Checks LM11C20 on Relay 4 (voltage) voltage on low but not on high position.

Checks switch with ohm meter. Does not know by checking B20 and C20 the switch is good. Checking across the switch on high and low position.

Checks A2 to A3 on Relay 4 (voltage).

Says, "Low is good, high is bad."

Subject did not know what he was doing - just guessing.

Says, "Relay 4 is bad. Replace it."

Subject 21, Circuit Three

Time in = 1013 Time out = 1037 Elapsed time = 24 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "The nav. lights are not working on a dim position."

Looks at diagram.

Checks L4E20 at T1 for voltage.

Says, "No voltage."

Checks same wire at switch for voltage.

Does not know the path's of influence.

Says, "No voltage."

Checks continuity of L4A20.

Says, "good."

Time out 10:19.

Time in 10:21.

Checks continuity of L4E20.

Says, "Need to replace L4E20."

Subject changed mind.

Checks continuity on L4E20.

Says "O.K.."

Checks continuity of L4B20.

Says, "Good."

Subject is guessing - is not sure.

Says, "Not sure where to go from here."

Plays around with switch.

Checks L4E20 at T1 voltage.

Gave up.

Says, "Replace switch?"

Gave up, move to next problem.

Subject 21, Circuit Four

Time in = 1038 Time out = 1049 Elapsed time = 11 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "The taxi light is not working."

Traces circuit for taxi light only.

Checks Relay 2 Points A1 to A2.

Says, "Good."

Checks continuity on R3.

Says, "R3 is good."

Checks continuity of line L34A14 between T1 and A1 on Relay 4.

Says, "It is open."

Says, "Replace wire L34A14."

Subject 22, Circuit One

Time in = 1508 Time out = 1513 Elapsed time = 5 minutes

Subject performed the following actions and articulated the following comments:

Operated the system.

Says, "The motor is not running."

Says, "The lights are O.K.. Therefore, everything is good up to T1."

Checks L41B20 from T1 to Point A (continuity check).

Says, "It is good."

Says, "The motor is bad."

Motor replaced.

Says, "It works O.K.."

Subject 22, Circuit Two

Time in = 1515 Time out = 1530 Elapsed time = 15 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "High works on low."

Says, "Low position is O.K.."

Looks at diagram.

Looks at Relay 4 in diagram.

Thinks and traces diagram with hi-liter.

Checks Relay 4 for continuity A3, A2.

Says, "Not good."

Says, "Replace Relay 4."

Subject 22, Circuit Three

Time in = 1533 Time out = 1547 Elapsed time = 14 minutes

Subject performed the following actions and articulated the following comments:

Operated the system.

Says, "The lights do not work on dim."

Says, "Steady works fine."

Operates system again.

Says, "The flasher works."

Traces the dim side.

Checks L4C20 to T1 (voltage).

Subject is not following the path of influence!

Says, "Zero volts. This means somewhere back has an open."

Checks L4C20 at R1.

Says, "Zero volts."

Checks L4D20 at R1.

System voltage.

Says, "The dim resistor is bad. Replace it."

Subject 22, Circuit Four

Time in = 1548 Time out = 1610 Elapsed time = 22 minutes

Subject performed the following actions and articulated the following comments:

Looks at diagram.

Operates the system.

Says, "It works on L/L ."

Says, "It does not work on taxi."

Looks at diagram, tracing the system.

Traces diagram on L/L position.

Finds the flow for the taxi light.

Checks at T1 and L33B14 (voltage).

Says, "Zero voltage."

Checks L33B14 at R3 (voltage).

Says, "Zero volts."

Checks at L34B14 at R3 (voltage).



Says, "Zero volts."

Checks L33B14 at T1 (voltage).

Says, "Zero volts."

Checks L34A14 between T1 and Relay 2.

Checks for continuity T1 and A1, on Relay 2.

Says, "It reads open line."

Subject is not sure if that is the problem or not.

Checks continuity on Relay 2 from X1 to X2.

Says, "O.K.."

Says, "Replace L34A14."

Subject 23, Circuit One

Time in = 0846 Time out = 0849 Elapsed time = 3 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "The problem is the motor is not energizing."

Looks at diagram.

Checks canon plug to see if voltage is going to motor

(Pt.A.)

22.9 Volts

Says, "O.K.."

Checks Pt. C.

Says, "No voltage. It is good."

Looks at diagram.

Says, "Replace motor."

Subject 23, Circuit Two

Time in = 0850 Time out = 0913 Elapsed time = 23 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "The problem is when the w/s is on high it still operates on low speed."

Looks at diagram.

Traces diagram with hi-liter.

Checks Relay 3 at X1 (voltage).

Says, "Voltage is there."

Checks Relay 3 across Pts. X1 and X2.

Says, "Not sure."

Checks for continuity between X1 and X2 on Relay 3.

Says, "Relay not good."

Says, "Repalce Relay 3." (0855)

*No change.*

Checks M13A14 (voltage).

Says, "Voltage is there."

Checks M12A14 (voltage).

Says, "Voltage is O.K.."

Checks M12A14 (in low position).

Says, "Voltage."

Says, "Replace R2." (0906)

R2 replaced.

*No change*

Says, "Open within Relay 4." (0913)

Subject 23, Circuit Three

Time in = 0915 Time out = 0919 Elapsed time = 4 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "No lights on dim, but I can hear the flasher. Dim path is not good."

Looks at diagram.

Traces diagram with hi-liter.

Checks L4D20 and R1 (voltage).

Says, "It is there. Good."

Checks L4C20.

Says, "It is not there. Replace R1."

Subject 23, Circuit Four

Time in = 0920 Time out = 0929 Elapsed time = 9 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "It does not work when the taxi light switch is turned on."

Looks at diagram.

Traces diagram with hi-liter.

Checks Relay 2 at X1.

Says, "Good."

Checks A2 on Relay 2.

Says, "Voltage is there."

Checks voltage at L34B14 at T1.

Says, "No voltage there."

Checks voltage at L34A14 at T1.

Says, "Zero volts."

Checks A1 on Relay 2.

Says, "Voltage is there."

Says, "Replace L34A14."

Subject 24, Circuit One

Time in = 1406 Time out = 1412 Elapsed time = 6 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Looks at diagram.

Says, "Motor is not working on rotation beacon."

Checks L41B20 for continuity from T1 to canon plug.

Says, "The wire is good. It is the motor. Replace the motor."

Subject 24, Circuit Two

Time in = 1413 Time out = 1435 Elapsed time = 22 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "Low is O.K.. High works on low."

Looks at diagram.

Says, "Relays are getting power because it working in both positions."

Says, "Actually Relay 4 may not be getting power."

Subject changed mind.

Traces diagram.

Checks for power on Relay 3 A1.

System ok.

Checks Relay 4 A3 high position.

6.8V

Checks Relay 4 A3 on low.

6.8V

Thinks.

Says, "Check A2 on Relay 4. System Voltage."

Says, "R2 is not part of the circuit when using high position."

Subject knows where the trouble areas are but is not sure.

Checks for continuity between A2 and A3 on Relay 4.

Says, "Open."

Subject 24, Circuit Three

Time in = 1437 Time out = 1449 Elapsed time = 12 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "The lights do not come on dim."

Looks at diagram.

Checks for voltage at L4E20 to make sure that switch is working.

Says, "System voltage. So switch is good."

Checks L4E20 at T1.

System.

Checks L4D20 at R1.

System voltage.

Checks the other side of R1.

Says, "Zero volts."

Says, "R1 is open."

Subject 24, Circuit Four

Time in = 1449 Time out = 1453 Elapsed time = 4 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "Works as L/L but not on taxi position."

Traces the diagram.

Uses hand to check Relay 2.

Says, "It is good."

Checks Pt. A2 on Relay 2 (voltage).

Says, "It is good."

Checks Pt. A1 on Relay 2.

System voltage.

Checks L34A14 at T1 (voltage).

Says, "Wire L34A14 is open."

Subject 25, Circuit One

Time in = 1009 Time out = 1011 Elapsed time = 2 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "Lights O.K.. Does not rotate."

Looks at drawing.

Checks voltage L41B20.

Says, "Replace motor."

Subject 25, Circuit Two

Time in = 1012 Time out = 1017 Elapsed time = 5 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "Motor runs O.K. in low."

Says, "Motor runs low speed when in high."

Studies drawing.

Traces drawing with hi-liter.

Says, "Replace Relay 4."

Subject 25, Circuit Three

Time in = 1019 Time out = 1022 Elapsed time = 3 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "No nav. lights in dim position. Flasher works.

Bright works."

Studies drawing.

Traces dim circuit.

Checks voltage L4D20 at R1.

Checks voltage L4C20 at R1.

Says, "Replace R1."

Subject 25, Circuit Four

Time in = 1022 Time out = 1028 Elapsed time = 6 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "No taxi light."

Studies the drawing.

Traces the path of influence for taxi circuit.

Operates the system.

Checks voltage L34A14 at A2 R1.

Checks voltage L34A14 at A2 R2.

Checks voltage L34A14 at A1, R2 and at T1.

Says, "L34A14 is open."

Subject 26, Circuit One

Time in = 1415 Time out = 1420 Elapsed time = 5 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "The rotating beacon is not working."

Checks L41B20 at Pin A and T1 for continuity.

Says, "Good continuity."

Checks Pin A to Pin C on the motor.

Says, "Open on the motor. Replace the motor."

Subject 26, Circuit Two

Time in = 1421 Time out = 1428 Elapsed time = 7 minutes

Subject performed the following actions and articulated the following comments:

Looks at diagram.

Operates the system.

Says, "Low is O.K.. High is not O.K.. Works on low always."

Checks M11A20 to ground (continuity).

Subject changed mind.



Checks A2 to A3 on Relay 4 (continuity).

Says, "Open on Relay 4. Replace Relay 4."

Subject 26, Circuit Three

Time in = 1444 Time out = 1500 Elapsed time = 16 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "It's not working on dim."

Looks at diagram and traces it with hi-liter.

Checks L4E20 switch to ground.

Says, "OK."

Checks L4E20 at T1.

Says, "Good."

Checks L4C20 at R1 (voltage).

Says, "Zero voltage."

Checks L4C20 at T1.

Says, "Zero voltage."

Checks L4B20 at T1.

Says, "Zero voltage."

Checks L4D20 at R1.

22.9 System.

Checks continuity of R1.

Says, "Open. Replace R1."

Subject 26, Circuit Four

Time in = 1501 Time out = 1509 Elapsed time = 8 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "It's not running on the taxi side."

Looks at diagram.

Traces diagram with hi-liter.

Checks L34A14 at A1 Relay 2.

System.

Checks L34A14 at T1.

Says, "Zero voltage."

Says, "Open wire L34A14."

Subject 27, Circuit One

Time in = 0858 Time out = 0902 Elapsed time = 4 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "Beacon does not rotate."

Looks at diagram.

Checks voltage at Pin A L41B20.

System.

Says, "Replace motor. It's bad."

Subject 27, Circuit Two

Time in = 0903 Time out = 0910 Elapsed time = 7 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Looks at the diagram.

Says, "Low side is O.K.. High side - low on high also."

Traces the diagram with hi-liter.

Checks continuity between A2 and A3 on Relay 4.

Says, "Replace Relay 4.

Subject 27, Circuit Three

Time in = 0912 Time out = 0917 Elapsed time = 5 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "Dim is not working."

Looks at diagram.

Checks voltage at T1.

System.

Checks voltage L4D20 at R1.

System.

Checks voltage L4C20 at R1.

Says, "Replace R1."

Subject 27, Circuit Four

Time in = 0921 Time out = 0939 Elapsed time = 18 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "The taxi light does not work."

Looks at diagram.

Traces diagram with hi-liter.

Checks continuity L22A20 from switch to ground.

No continuity.

Checks continuity L22A20 from switch to X1 on Relay 2.

Good.

Checks continuity X1 to X2 on Relay 2.

Checks voltage on wire L34A14 at T1.

Says, "Zero volts."

Checks voltage on Relay 2 at A1.

System.

Says, "Open on L34A14."

Subject 28, Circuit One

Time in = 1314 Time out = 1324 Elapsed time = 10 minutes

Subject performed the following actions and articulated the following comments:

Looks at diagram.

Operates the system.

Says, "Not rotating." (Rotating Beacon)

Checks L41B20 for voltage at T1.

22.2 Volts

Says, "Wire is O.K.."

Checks L41B20 at Pin A.

Says, "L41B20 is open."

*No change.*

Says, "Replace motor."

Subject 28, Circuit Two

Time in = 1325 Time out = 1342 Elapsed time = 17 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "Low is O.K.. High works with low speed."

Looks at diagram.

Traces diagram with hi-liter.

Checks M10B14 at A1 Relay 3 (voltage).

Says, "O.K.."

Checks M10B14 at A3 Relay 4 (voltage).

Says, "O.K.."

Checks continuity A3 to A2 on Relay 4.

Says, "Open. Replace Relay 4."

Subject 28, Circuit Three

Time in = 1343 Time out = 1353 Elapsed time = 10 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Looks at the diagram.

Checks continuity flash to dim L4A20.

Says, "Open L4E20. Replace wire."

*No change. (1337)*

Subject did not know what was wrong with the system even though subject operated it.

Checks L44E20 to LD20 at R1 for continuity.

Says, "Open L4E20. Replace it." (1346)

*No change.*

Checks L4E20 again.

Says, "Good."

*Checks L4B20 for continuity. Says, "Good."*

Checks R1 for continuity.

Says, "R1 is open. Replace R1."

Subject 28, Circuit Four

Time in = 1357 Time out = 1403 Elapsed time = 6 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "There is no taxi light."

Looks at diagram.

Checks R3 for continuity.

Says, "O.K.."

Operates system again.

Traces system.

Checks voltage A2 to ground on Relay 1.

Says, "Good."

Checks voltage A2 to ground on Relay 2.

Says, "Good."

Checks L34A14 at T1.

Says, "Zero voltage."

Checks continuity for L34A14.

Says, "Open wire. Replace L34A14."

Subject 29, Circuit One

Time in = 1112 Time out = 1116 Elapsed time = 4 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "Not rotating."

Looks at diagram.

Checks continuity at Pin A L41B20 to continuity, ground.

Says, "Bad motor."

Subject 29, Circuit Two

Time in = 1117 Time out = 1143 Elapsed time = 26 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "Low is O.K.. High is stuck on low."

Looks at diagram.

Traces diagram with hi-liter.

Checks M11C20 at switch at high side.

Says, "No voltage."

Checks continuity on Relay 4 between A3 to A2.

Says, "Replace Relay 4."

Subject 29, Circuit Three

Time in = 1145 Time out = 1150 Elapsed time = 5 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "Dim is not working."

Looks at diagram.

Checks L4B20 at T1 (voltage).

Says, "Zero voltage."

Checks L4C20 at R1 (voltage).

Says, "Zero voltage."

Checks L4D20 at R1 (voltage).

22.9 System.

Says, "R1 is bad. Replace it."

Subject 29, Circuit Four

Time in = 1151 Time out = 1157 Elapsed time = 6 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "L/L works. Taxi does not work."

Looks at diagram.

Checks L33B14 at R3 (voltage).

Says, "Zero voltage."

Checks L33B14 at R3 other side.

Says, "Zero voltage."

Checks L34A14 at T1.

Says, "Zero voltage."

Checks L34A14 at A1 (voltage).

System.

Says, "Wire L34A14 is open. Replace."

Subject 30, Circuit One

Time in = 1130 Time out = 1134 Elapsed time = 4 minutes

Subject made one measurement with voltmeter.

Subject was correct with first diagnoses.

Circuit two

Time in = 1135 Time out = 1150 Elapsed time = 15 minutes

Subject made two measurements with voltmeter.

Subject was correct with first diagnoses.

Circuit three

Time in = 1200 Time out = 1206 Elapsed time = 6 minutes

Subject made four measurements with voltmeter.

Subject was correct with first diagnoses.



Circuit four

Time in = 1207 Time out = 1215 Elapsed time = 8 minutes

Subject made three measurements with voltmeter.

Subject was correct with first diagnoses.

## APPENDIX F

## RAW DATA FOR CONTROL SUBJECTS

CIRCUIT ONE REFERS TO THE ROTATING BEACON CIRCUIT.

CIRCUIT TWO REFERS TO THE WIPER MOTOR CIRCUIT.

CIRCUIT THREE REFERS TO THE NAV. LIGHTS CIRCUIT.

CIRCUIT FOUR REFERS TO THE LANDING / TAXI LIGHT CIRCUIT.

Subject one, Circuit one

Time in = 0900 Time out = 0906 Elapsed time = six minutes

Subject performed the following actions and articulated the following comments:

Operated the system.

Commented that beacon does not rotate.

Studied the schematic.

Commented, "Must have voltage at T one because lights work."

Checks voltage at pin A and ground.

Says "There is voltage at pin A."

Says "Replace the motor."

*That is the solution.*

Subject one, Circuit two

Time in = 0906 Time out = 0926 elapsed time = 20 minutes

Subject performed the following actions and articulated the following comments:

Operated system.

Commented: " Motor runs in low speed, ok. Motor runs at low in high speed position."

Studied drawing.

Talks to himself about how the system works.

Studied drawing.

Correctly explains to himself how the system works.

He thinks the switch between A3 and A1 in relay four is stuck open.

Checks relay three by feel.

Says, "relay four is working all the time."

Says, "could be an open between A3 and A2 in relay four.

Says, " I will check continuity between A3 and A2 in relay four.

turns circuit off.

Does not isolate wires.

Places an ohmmeter at the connections A3 to A2 relay four.

Says he has some continuity.

Studied drawing.

Says, "there has to be an open between A3 to A2 in relay four."

Places the control switch in high position.

Checks voltage A2 to ground, relay four.

Checks voltage A3 to ground, relay four.

Says, "replace Relay four."

*That is the correct solution.*

Subject one, Circuit three

Time in = 0927 Time out = 0935 Elapsed time = eight minutes.

Subject performed the following actions and articulated the following comments:

Operates the circuit.

Says, "Bright lights are OK but no dim."

Studies Drawing.

Correctly identifies the dim circuit on the schematic by tracing with a hi-liter.

Says, " I am going to cut the circuit in half and check voltage.

Checks voltage at L4E20 and T1--- shows 23 volts

Checks voltage at L4D20 and R1 --- shows 23 volts

Checks voltage at L4C20 and R1--- shows 0 volts

Says, "replace R1."

*That is the correct solution.*

Subject one, Circuit four.

Time in = 0935 Time out = 0940 Elapsed time = five minutes

Subject performed the following actions and articulated the following comments:

Operated the circuit.

Said, "Landing light is ok."

Studied the drawing.

Operated the circuit a second time.

Says, " The taxi light goes through the resistor, but for some reason can't."

He places his hand on relay two and flips control switch back and forth between taxi and landing position.

Says, " Relay must be working."

Checks voltage at A1 to ground on relay two.

Checks voltage at L32A14 to ground at T1.

Checks voltage at L34A14 at T1Says, " Replace wire L34A14."

*That is the correct solution.*

Subject two, Circuit one

Time in = 1639 Time out = 1646 Elapsed time = seven minutes

Subject performed the following actions and articulated the following comments:

Operated the system.

Says, "Will not rotate."

Studied the schematic.

Checks continuity between Pin A and ground.

Says, "open motor."

Checks continuity from pin A to T1.

Says, "ok."

Says, "The motor needs to be replaced."

*That is the correct solution.*

Subject two, Circuit two

Time in = 1647 Time out = 1712 Elapsed time = 25 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "low speed is ok, but the high runs in low speed."

Looks at schematic and traces it with a hi-liter.

Checks continuity M13A14 at A3 and to connection on T1.

Checks continuity M13A14 to A2 on the other side of relay four.

Says, "Circuit is ok. No need to check to check this circuit because it works on the low speed setting."

Checks voltage at X2 on relay four and determines it is 0 volts.

Checks continuity between A2 and A3 on relay four.

Says, "Relay four is open. Replace it."

Subject two, Circuit three

Time in = 1714 Time out = 1720 Elapsed time = six minutes

Subject performed the following actions and articulated the following comments:

Operated the system.

Says, "Dim does not work."

Studies the schematic.

Checks continuity of wires L4E20 and L4D20 with one measurement.

Says, "Ok."

Checks R1 for continuity.

Says, "Replace R1."

*That is the correct solution.*

Subject two, Circuit four

Time in = 1721 Time out = 1730 Elapsed time = nine minutes

Subject performed the following actions and articulated the following comments:

Operated the system.

Says, "Taxi light does not work."

Studies schematic and traces the circuit with finger tip.

Checks relay two by placing hand on it and moving switch several times between landing and taxi position.

Checks continuity between A2 on relay one and A2 relay two.

Says, "ok."Checks voltage at T1 and wire L34A14.

Says, "0 volts."

Says, "There must be an open in wire L34A14."

*That is the correct solution*

Subject three, Circuit one

Time in = 1004 Time out = 1009 Elapsed time = five minutes

Subject performed the following actions and articulated the following comments:

Operated the system.

Says, "The motor is not working."

Studied the schematic.

Checks voltage at wire L41B20 and T1 to ground. Voltage is 24 volts.

Says, "Wire is Ok."

Checks continuity of wire L41B20.

Says, "I'm doing this to see if an open exists in this wire."

Checks voltage pin A to ground and meter indicates 24 volts.

Says, "Leads me to believe it is a bad motor. Replace it."

*That is the correct solution.*

Subject three, Circuit two

Time in = 1011 Time out = 1026 Elapsed time = 15 minutes

Subject performed the following actions and articulated the following comments:

Operated the system.

Says, "It is not running on High. High is the same as low."

Studies the schematic.

Traces a part of the schematic with a hi-liter.

Spends additional time studying the schematic.

Checks continuity between points A3 and A2 of relay four.

(the switch is off.)

Studies the schematic more.

Turns the switch to low position.



Quickly took two voltage readings without indicating where.

Says, "Circuit A3 to A2 in relay four is open."

Says, "Replace relay four."

That is the correct solution.

Subject Three, Circuit Three

Time in = 1028 Time out = 1042 Elapsed time = 14 minutes

Subject performed the following actions and articulated the following comments:

Operated the system.

Says, "No nav. lights."

checks voltage at L4F20 and T1.

Says, "No voltage."

Operates system again.

Now he realizes that he has bright but no dim.

Tracing the circuit with tip of finger.

Operates the circuit again, in both dim and bright.

Studies the schematic.

Checks voltage L4D20 and T1 to ground.

Says, "Got 24 volts. It is ok."

Checks voltage across R1.

Checks continuity of R1.

Looks puzzled.

Says, "R1 is open."

That is the correct solution.

Subject Three, Circuit Four

Time in = 1044 Time out = 1054 Elapsed time = ten minutes

Subject performed the following actions and articulated the following comments:

Operated the system.

Says, "Landing light will work, but Taxi light will not."

Studied the schematic.

Traces parts of the schematic with Hi-liter.

Checks voltage at A2 on relay two.

Says, "That was all right."

Checks voltage L34B14 at R3.

Checks voltage at L34A14 and connection to relay two to ground.

Says, "That was good."

Checks voltage L34A14 at T1 to ground.

Repeats voltage check at connection of L34A14 and relay two.

Says, "There is an open in wire L34A14. Replace it."

*That is the correct solution.*

Subject Four, Circuit one

Time in = 1021 Time out = 1027 Elapsed time = six minutes

The subject performed the following actions and articulated the following comments:

Looked at the schematic.

Operated the system.

Checked voltage at L41B20 and T1 to ground.

Voltage was confirmed.

Checked voltage at L42B20 and pin A on cannon plug.

Voltage was confirmed.

Looked at the schematic.

Said to replace the motor in the rotating beacon.

*That is the correct solution.*

Subject Four, Circuit Two

Time in = 1027 Time out = 1056 Elapsed time = 29 minutes

The subject performed the following actions and articulated the following comments:

Looked at the schematic.

Operated the system.

Looked at the schematic.

Checked voltage at the switch with switch in the high position (M11B20 to ground). Determined that was voltage at that location.

Checked voltage at M11C20 to ground. Determined that voltage existed.

Looked at the schematic.

Checked voltage at M10B14 to ground.

Says, "Got system, there."

checking voltage at M10B14 and A3 to ground on relay four.

Determined that system voltage existed.

Looked at diagram.

Checked voltage at M13A14 at T1 to ground. Determined that system voltage existed.

Checked voltage at M13B14 at T1 to ground.

Says, "I've got seven.three volts here."

Says, "That resistor is bad. Replace it."

*That is not the correct solution. Time is 1041.*

*Subject is informed of incorrect solution and asked to continue.*

Looked at diagram and traced part of it with his finger tip.  
Checked voltage at A3 and relay four to ground. Found system voltage.

Checked voltage at M12A14 to ground. *Researcher's note: I don't know if subject is testing at connection of M12A14 and T1 or M12A14 and relay four.*

Subject said that system voltage was discovered.

Subject made the observation that all testing had been conducted with switch in the high position.

The switch was relocated to the low position.

Looked at schematic.

Said that the switch in relay is probably stuck open. Relay four should be replaced.

*That is the correct solution.*

Subject Four, Circuit Three

Time in = 1057 Time out = 1101 Elapsed time = four minutes

The subject performed the following actions and articulated the following comments:

Looked at schematic.

Operated the system.

Checked voltage at L4A20 and the dim/bright switch and discovered zero voltage. *Researchers notes: The system was turned off.*

Subject said, "You got me on that one."

Measured voltage again after turning the system on and obtained a reading of system voltage.

Checked voltage at L4E20 at T1 and ground.

Says, "System voltage."

Checking voltage at L4D20 and R1.

Says, "System voltage."

Checking voltage at L4C20 and R1.

Says, "Replace R1 because it is bad."

*That is the correct solution.*

Subject Four, Circuit Four

Time in = 1103    Time out = 1110    Elapsed time = seven minutes

The subject performed the following actions and articulated the following comments:

Operates the system while looking at the schematic.

Checks voltage at L22A20 and switch.

Says, "got voltage there."

Checks voltage at L22A20 and X1 on relay two.

Says, "Got voltage there."

Checks voltage at X2 (ground connection) on relay two.

Says, "Got zero voltage, there. Replace relay two."

*Subject informed that his diagnoses is an incorrect solution and to please continue.*

Checks voltage at A2 and Relay two.

Says, "Got system."

Checks voltage L34A14 and T1 to ground.

Says, "I think there is a break in Wire L34A14. Let's try replacing it."

*That is the correct solution.*

Subject Five, Circuit One

Time in = 1011 Time out = 1017 Elapsed time = six minutes

The subject performed the following actions and articulated the following comments:

Operated the system.

Looks at the schematic.

Says, "I think there is a bad motor because the lights are Ok."

Checks voltage at cannon plug (Pin A to ground).

Finds voltage.

Says, "There is a bad motor, but I'm not sure."

Checks ohms from pin A to pin C.

Finds infinity

Says, "The motor is bad, replace it."

*That is the correct solution.*

Subject Five, Circuit Two

Time in = 1019 Time out = 1051 Elapsed time = 32 minutes

The subject performed the following actions and articulated the following comments:

Looks at schematic.

Says, "Wiper motor is low speed condition in both positions of the switch."

Looks at the schematic.

Operates the system.

Looks at the schematic.

Traces on the schematic with a hi-liter.

Checks voltage at A1 to ground on relay three.

Says, "No voltage."

Checks Voltage at A2 and relay three.

Says, "Bad relay."

Says, "No-No-No. I have to turn the switch to the high position."

Checks voltage at M13A14 and T1 to ground. No remark about findings.

Checks voltage at M13A14 and A3 on relay four to ground.

Says, "system."

Checks voltage M12A14 to ground.

Says, "No voltage."

*Researchers notes: Don't know which end of M12A14.*

Says, "I got ahead of myself."

Checks voltage M12B14 to ground.

Says, "Got system."

*Researchers notes: Don't know which end of M12B14.*

Checks ohms across R2.

Says, "OK, reads one.two K ohms."

Says, "We have a problem with the motor."

Says to replace the motor.

*Subject is informed that diagnoses is incorrect and asked to continue.*

Says, "I don't know what to do. I would like to move ahead."

*Attempt to solve problem is abandoned.*

Subject Five, Circuit Three

Time in = 1052 Time out = 1108 Elapsed time = 16 minutes

The subject performed the following actions and articulated the following comments:

Studied the schematic.

Operated the system.

Checked voltage at T1 and ground.

*Researchers notes: Don't know at what point on T1.*

Says, "No power."

Checks voltage at L4A20 and switch (unidentified) to ground.

Says, "No power."

Checks voltage at L1A20 and unidentified location to ground.

Says, "Got voltage."

Says, "Might be either an open wire or bad steady/flash switch."

*Subject realized that entire system was off during previous measurements.*

Says, "The nav. light does not dim."

Says, "There is system voltage going into the steady/flash switch."

Checks voltage at L4D20 and T1 to ground.

Says, "Got voltage."

Checks voltage at T1 and L5A20 to ground.

Checks voltage at T1 and L5B20 to ground.

Checks voltage at T1 and L5C20 to ground.

Says, "No voltage going into the nav. lights."

Looks at schematic and traces with finger tip.



Checks voltage at L4D20 and R1 to ground. Finds no voltage.

Checks voltage at L4C20 and R1 to ground.

Says, "R1 is open. Replace it."

*That is the correct solution*

Subject Five, Circuit Four

Time in = 1109 Time out = 1115 Elapsed time = six minutes

The subject performed the following actions and articulated the following comments:

Operated the system.

Says, "Nothing wrong with the landing lights, but the taxi light position will not work."

Checks voltage at R3 and the end of unidentified wire to ground.

Says, "No voltage. Not the problem."

Checks voltage At A1 on relay two to ground.

Says, "Got voltage. Ok."

Checks voltage L34A14 on T1 to ground.

Finds no voltage.

Says, "Wire L34A14 is open. Replace it."

*That is the correct solution.*

Subject Six, Circuit One

Time in = 1004 Time out = 1010 Elapsed time = six minutes

The subject performed the following actions and articulated the following comments:

Operated the system.

Looked at the schematic.

Says, "Not rotating."

Says, " Motor and lights are independent of each other."

Checks voltage at L41B20 and pin A on cannon plug to ground.

Says, "Got voltage."

Looks at schematic.

Says, "It could be the motor."

Checks ohms from pin A to pin C.

Says, "Infinity."

Looks at the schematic.

Traces part of the wiring on the schematic with finger tip.

Says, "Motor is bad, replace it."

*That is the correct solution.*

Subject Six, Circuit Two

Time in = 1011 Time out = 1026 Elapsed time = 15 minutes

The subject performed the following actions and articulated the following comments:

Operated the system.

Looked at the schematic.

Says, "Running through R2 all the time."

Looks at the schematic and traces part of the wires with a Hi-liter.

Studies the system.

Subject is really thinking and studying the schematic in great detail.

Says, "I think it is relay four, but I am not sure."

Looks at relay four.

Checks relay four by moving hi/low switch back and forth between positions and feeling relay four.

Says, "No."

Finds a loose wire on relay four but says, "That is not the problem."

Checks A2 and A3 (ohms) on relay four.

Says, "No reading."

Says, "I think it is relay four. Let's replace it and find out."

*That is the correct solution.*

Subject Six, Circuit Three

Time in = 1027 Time out = 1040 Elapsed time = 13 minutes

The subject performed the following actions and articulated the following comments:

Operated the system.

Looks at the schematic.

Says, "Probability some kind of open in the dimming circuit."

Says, "It does not work in either position, so it not before T1. So it could be L4D20 or L4C20. Exclude L4D20. No, I made a mistake, L4D20 could be the problem."

Checks L4E20 (ohms) from switch to T1.

Says, "It is good."

Traces the schematic with finger tip.

Checks L4B20 (ohms) from switch to T1.

Says, "It is good."

Looks at schematic and then at board.

Checks R1 for continuity with ohm meter.

Says, "R1 needs replacing."

*That is the correct solution.*

Subject Six, Circuit Four

Time in = 1041 Time out = 1047 Elapsed time = six minutes

The subject performed the following actions and articulated the following comments:

Operated the system.

Says, "No taxi light."

Studies the schematic.

Traces the schematic with a Hi-liter.

Checks voltage at X2 on relay two to ground.

Says, "It is good."

Checks voltage at A1 to ground on relay two.

Says, "It is good."

Checks voltage at L34A14 and T1 to ground.

Says, "Nothing."

Says, "Let me think for a second."

Says, "L34A14 is open, replace it."

*That is the correct solution.*

Subject Seven, Circuit one

Time in = 1010 Time out = 1015 Elapsed time = five minutes

The subject performed the following actions and articulated the following comments:

Operated the system.

Says, "Lights are on, but motor will not work."

Looks at schematic.

Checks wire (voltage) L41B21 at cannon plug (pin A).

Says, "no reading."

Checks L41B21 at T1 (voltage) to ground.

Says, "system voltage."

Says, "Motor needs to be replaced."

*That is the correct solution.*

Subject Seven, Circuit Two

Time in = 1016 Time out = 1032 Elapsed time = 16 minutes

The subject performed the following actions and articulated the following comments:

Operated the system.

Looks at the schematic.

Says, "System is not working in the high speed position."

Says, "Works at low speed in both positions."

Traces the schematic with a Hi-liter.

Checks voltage between A3 and A2 on relay four.

Says, "14.seven volts. Ok. Because it is running. The motor No-No because it is going through the resistor R3."

Says, "Relay four is bad. Let's replace it."

*That is the correct solution.*

Subject Seven, Circuit Three

Time in = 1034 Time out = 1045 Elapsed time = 11 minutes

The subject performed the following actions and articulated the following comments:

Operated the system.

Says, "In the flashing position, the lights do not work."

Looks at the schematic.

Operates the system again.

Says, "Dim/steady, no lights."

Says, "Dim/flash, you can hear the flasher working but no lights."

Looks at the schematic.

Checks voltage at L4D20 and R1.

Says, "ok."

Checks continuity across R1.

Says, "700 ohms."

Checks voltage at R1 and L4C20.

Says, "System."

Isolates R1 and measures continuity across it.

Says, "Replace R1."

*That is the correct solution.*

Subject Seven, Circuit Four

Time in = 1046 Time out = 1056 Elapsed time = ten minutes

The subject performed the following actions and articulated the following comments:

Operated the system.

Says, "Taxi light is not working."

Traces the schematic.

checks voltage L22A20 at switch.

Says, "ok."

Checks voltage at X1 on relay two.

Says, "ok."

checks voltage across X1 and X2 on relay two.

Says, "Got system voltage."

Checks continuity between X1 and X2 on relay two.

Says, "Got 106.three ohms."

checks continuity A3 relay one to A2 relay two.

Says, "Ok."

Checks continuity of wire L34A14.

Says, "Wire is broken, replace it."

*That is the correct solution.*

Subject Eight, Circuit One

Time in = 0958    Time out = 1005    Elapsed time = seven minutes

The subject performed the following actions and articulated the following comments:

Operated the system.

Looked at the schematic.

Opened box containing the circuit breakers.

Traced schematic with finger tip.

Checks voltage at T1 to ground.

Says, "22 Volts."

Checks voltage at pin A on cannon plug to ground.

Says, "system voltage."

Says, "motor is bad, replace it."

*That is the correct solution.*

Subject Eight, Circuit Two

Time in = 1007    Time out = 1020    Elapsed time = 13 minutes

The subject performed the following actions and articulated the following comments:

Operated the system.

Looks at diagram.

Operates the system.

Checks voltage at X1 on relay three.

Checks voltage at X2 on relay three.

Determines system voltage at both locations.

Checks voltage at A2 on relay three.

Checks voltage at M10B14 and A1 on relay three.

Says, "system."

Checks voltage M10B14 and A3 on relay four.

Says, "system."

checks voltage M12A14 at relay four.

Says, "seven volts."

Checks voltage at X1 on relay four with switch in low position.

Checks voltage at X1 on relay four with switch in high position.

Checks voltage M12A14 at T1 with switch in low position.

Repeats measurement with switch in high position.

Says, "Relay four is bad between points A3 and A2, replace it."

*That is the correct solution.*

Subject Eight, Circuit Three

Time in = 1021 Time out = 1033 Elapsed time = 12 minutes

The subject performed the following actions and articulated the following comments:

Operated the system.

Looks at schematic.

Checks voltage at L4B20 and T1.

Gets system.



Checks voltage L4D20 and T1.

Gets system.

Checks voltage L4D20 and R1.

Gets system.

Checks voltage L4E20 at Dim switch.

Gets system.

Traces the schematic.

Checks voltage at L4C20 at T1.

Gets nothing.

Checks voltage at L4B20 at T1.

Gets nothing.

Traces the schematic.

Checks voltage at L4F20.

Gets nothing.

*Researchers notes: L4F20 and unknown end.*

Studies schematic.

Says, " Lets take a shot and go for R1."

Subject Eight, Circuit Four

Time in = 1034 Time out = 1040 Elapsed time = six minutes

The subject performed the following actions and articulated the following comments:

Operated the system.

Studied the schematic.

Checks voltage at X1 on relay two.

Gets system voltage.

Traces schematic in detail.

Checks relay one A2 for voltage.

Checks relay two at A2 for voltage.

Checks relay two at A1 for voltage.

Gets system voltage at each of the above measurements.

Checks voltage at L34A14 at T1 to ground.

Gets no voltage.

Says, "Wire L34A14 is open. Replace it."

*That is the correct solution.*

Subject Nine, Circuit One

Time in = 1008    Time out = 1015    Elapsed time = seven  
minutes

Subject performed the following actions and articulated  
the following comments:

Looked at schematic.

Says, "Lights are on, but not rotating."

Checks 141B20 at T1 to pin A for continuity.

Says, "Let me think about this for awhile."

Says, "L4B20 wire is good."

Says, "Must be an open in the motor."

*That is the correct solution.*

Subject Nine, Circuit Two

Time in = 1017    Time out = 1046    Elapsed time = 29 minutes

Subject performed the following actions and articulated  
the following comments:

Operated the system.

Says, "Only runs on low."

Traces schematic with hi-liter.

Studies the schematic in detail.

Traces the Hi position with different color hi-liter.

Checks voltage at X1 on relay three.

Finds system voltage.

Checks voltage at A2 on relay three.

Finds system voltage.

Checks voltage at A3 on relay four.

Finds system voltage.

Checks voltage at X1 on relay four.

Says, "nothing there."

Checks voltage A1 to A2, relay four.

Says, "Normal."

Checks voltage A1, relay four with switch in high and then low position.

In low position = no voltage

In high position = no voltage

Says, "relay four is bad, replace it."

*That is the correct solution.*

Subject Nine, Circuit Three

Time in = 1048 Time out = 1101 Elapsed time = 13 minutes

Subject performed the following actions and articulated the following comments:

Operated the system.

Looks at the schematic.

Says, "No dim. You go to dim they shut off."

checks voltage between unknown ends of L4E20 and L4B20.

Isolates L4C20 and checks continuity on it.

Does same for L4B20.

Checks continuity on L4F20.

Checks for continuity on resistor one.

Says, "infinity, that's the problem, replace it."

*That is the correct solution.*

Subject Nine, Circuit Four

Time in = 1102   Time out = 1109   Elapsed time = seven  
minutes

Subject performed the following actions and articulated  
the following comments:

Operated the system.

Says, "Taxi light is not working."

Looks at schematic.

Checks voltage at X1 on relay two.

Says, "ok."

Checks voltage at A2 on relay one.

Says, "system again."

Checks voltage at A2 and relay two to ground.

says, "system voltage."

Checks voltage A1 and relay two.

Checks voltage L34A14 and T1.

Says, "L34A14 is open, replace it."

*That is the correct solution.*

Subject Ten, Circuit one

Time in = 0951   Time out = 1010   Elapsed time = 19 minutes

Subject performed the following actions and articulated  
the following comments:

Operated the system.

Looks at schematic.

Says, "Motor is not operating."

checks voltage at T1 and wire L41B20.

No voltage.

Checks voltage at switch and wire L41A20.

Says, "That wire is open replace it."

*Incorrect diagnoses*

Checks voltage at L41B20 and T1.

Says, "It is hard to reads the numbers and letters on the wires."

Says, "I think I took the wrong reading."

Checks voltage at Pin A on cannon plug.

Says, "Motor needs to be changed."

*That is the correct solution.*

Subject Ten, Circuit Two

Time in = 1010 Time out = 1052 Elapsed time = 42 minutes

Subject performed the following actions and articulated the following comments:

Looks at schematic.

Operates the system.

Says, "Wiper system indicating the same speed on both Hi and low positions, indicating both high."

Says, "Relay four should not be working at all but it is not the relay."

Says, "There is a short at the control switch, it needs to be replaced."

*Incorrect solution.*

Says, "Need to look at relay three. Relay has nothing to do with the problem."

Checks voltage M10B14 and somewhere.

Checks continuity of M10B14.

Says "Zero resistance so it is a good wire, not the problem."

Studies the schematic.

Checks continuity of M11C20.

Checks continuity of M11B20.

Says, "I give up."

*Failed attempt*

Subject Ten, Circuit Three

Time in = 1052 Time out = 1059 Elapsed time = seven minutes

Subject performed the following actions and articulated the following comments:

Looks at schematic.

Determines that nav. lights do not work.

Checks voltage at T1 and L4F20.

Says, "No voltage."

Says, "Bright shows voltage. Dim shows no voltage."

Says, "Problem in the dim circuit."

Checks voltage at wire L4D20 and R1.

Says, "System."

Checks voltage at L4C20 and R1.

Says, "nothing there. Replace R1."

*That is the correct solution.*

Subject Ten, Circuit Four

Time in = 1060 Time out = 1060 Elapsed time = 0 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Looks at the schematic.

Says, "I'm clueless. I don't know what I'm doing."

*Abandons solution.*

Subject 11, Circuit One

Time in = 1630 Time out = 1638 Elapsed time = eight minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "Motor is not working."

Looks at schematic.

Checks voltage at L41B20 and T1.

Finds system voltage.

Checks voltage at L41B120 and Pin A.

Finds system voltage.

Says, "Open in motor, replace it."

*That is the correct solution.*

Subject 11, Circuit Two

Time in = 1638 Time out = 1650 Elapsed time = 12 minutes

Subject performed the following actions and articulated the following comments:

Operated the system.

Says, "Low ok. High works in low speed setting."

Looks at schematic.

Checks voltage at A3 and relay four.

Says, "ok."

Checks voltage at X1 and relay four.

Says, "0 volts."

Checks A2 to A3 continuity on relay four.

Says to replace relay four.

*That is the correct solution.*

Subject 11, Circuit Three

Time in = 1650 Time out = 1700 Elapsed time = ten minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "No dim."

Looks at schematic.

Checks continuity of R1.

Says, "Replace R1."

*That is the correct solution.*

Subject 11, Circuit Four

Time in = 1700 Time out = 1708 Elapsed time = eight minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "No taxi light."

Checks R3 for continuity.



Checks X1 on relay two.

Says, "Got system voltage."

Checks voltage X2 on relay two.

Says, "Got zero."

Checks voltage at L34A14 and T1.

Says, "Got zero."

Checks voltage at L34A14 and A1 on relay two.

Says, "That wire is open."

Subject 12, Circuit One

Time in = 1641 Time out = 1646 Elapsed time = five minutes

Subject performed the following actions and articulated the following comments:

Operated system.

Says, "Motor is not turning."

Looks at schematic.

Checks voltage at L41B20 and Pin A.

Says, "got system."

Checks continuity between Pin A and Pin C on Beacon unit.

Finds no continuity.

Says to replace the motor.

*That is the correct solution.*

Subject 12, Circuit Two

Time in = 1642 Time out = 1652 Elapsed time = ten minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "Low Ok. High does not work. High works in low."

Looks at schematic.

Checks continuity A2 to A3 relay four.

Checks continuity A1 to A2 relay four.

Says, "I'm guessing that the contacts in relay four are open all the time. Replace relay four."

Subject 12, Circuit Three

Time in = 1658    Time out = 1701    Elapsed time = three minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "Dim does not work."

Looks at schematic.

Checks R1 for continuity.

Says to replace R1.

*That is the correct solution.*

Subject 12, Circuit Four

Time in = 1703    Time out = 1709    Elapsed time = six minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "No taxi lights."

Looks at schematic.

Checks R3 for open with continuity checker.

Says, "Ok."

Checks L33B14 for continuity.

Checks L34B14 for continuity.

Checks L34A14 for continuity.

Says "That's the one. Replace it."

*That is the correct solution.*

Subject 13, Circuit One

Time in = 1533 Time out = 1544 Elapsed time = 11 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Studies the schematic.

Says, "The motor is not operating. Probably an open in wire L41B20 but going to check it."

Put voltmeter across the ends of wire L41B20 with the wire disconnected at pin A.

Says, "zero volts."

Measured voltage at T1 to ground.

Measured resistance Pin A at motor and to airframe.

Showed infinity.

Measured resistance pin A to pin C.

Showed infinity.

Says, "Replace the motor."

*That is the correct solution.*

Subject 13, Circuit Two

Time in = 1545 Time out = 1604 Elapsed time = 19 minutes

Subject performed the following actions and articulated the following comments:

Operated the system.

Says, "Runs low both ways."

Studies the schematic.

Traces part of the schematic with a Hi-liter.

Runs motor with switch in high position.

Checks voltage between the ends of wire M10B14.

Checks voltage at M10B14 and A3 on relay four.

Runs motor with switch in high speed position again.

Studies schematic.

Opens control panel.

Runs motor with switch in high position again.

Studies schematic.

Takes voltage reading across switch.

Says, "Zero volts."

Takes voltage across A3 and A2 in relay four.

Says, "It is open. Got 14.seven volts. Replace it."

*That is the correct solution.*

Subject 13, Circuit Three

Time in = 1604 Time out = 1615 Elapsed time = 11 minutes

Subject performed the following actions and articulated the following comments:

Operated the system.

Says, "Does not go in dim position. Everything else works."

Studies schematic.

Hi-lited dim circuit.

Says, "I'm going to measure volts across ends of wire L4E20."

Wire was connected at both ends.

Used voltmeter as ammeter

No reading.

Turned off master.

Isolated L4E20 and checked resistance.

It showed continuity.

Removed wire L4D20 and checked resistance across it.

Showed continuity.

Checked continuity of R1.

It showed infinity.

Says, "Replace R1."

*That is the correct solution.*

Subject 13, Circuit Four

Time in = 1615 Time out = 1640 Elapsed time = 25 minutes

Subject performed the following actions and articulated the following comments:

Operated the system.

Says, "Landing light does work. Taxi light does not work."

Checks ohms across L32A14 with voltage applied to system.

No resistance was shown.

Checked voltage across L32A14 with voltage applied to system.

No voltage difference.

Checked voltage at X1 and relay two with switch off.

Showed zero voltage.

Checked voltage across switch with switch open and said that he found voltage.

Says, "Replace switch."

*That is not the correct solution.*

Checked voltage across R3. Said no voltage.

Checked voltage across L33B14. Said no voltage.

Checked voltage across L34A14. Said showed voltage.

Says, "L34A14 is open."

Says, "Replace the wire."

*That is the correct solution.*

Subject 14, Circuit One

Time in = 1520 Time out = 1530 Elapsed time = ten minutes

Subject performed the following actions and articulated the following comments:

Looked at schematic.

Operated the system.

Says, "Beacon does not rotate."

Opens control panel.

Searching for a wire.

Studies the schematic.

Removes plug from beacon unit.

Checks voltage at Pin A and wire L41B20.

Says, "No volts."

Says, "Wire L41B20 is open, but I'm not ready to replace it.

I want to check some more."

Studies the schematic.

Operates the system.

Discovers he checked for voltage without the switch on.

Checks voltage at Pin A and wire L41B20 again and finds voltage.

Checks resistance between Pin A at motor to Pin C at motor.

Says, "Infinity."

Says, "Replace the motor."

*That is the correct solution.*

Subject 14, Circuit Two

Time in = 1531 Time out = 1537 Elapsed time = six minutes

Subject performed the following actions and articulated the following comments:

Operated the system.

Says, "It runs in low speed in both switch positions."

Studies the schematic.

Operates the system while putting hand on relays. Says, "I want to see if I can tell if a relay is not working."

Held head against side of relay.

Studies schematic.

Hi-lites part of the schematic.

Says, "I feel I do not understand the system well enough to finish or solve the problem. I want to move on to the next problem."

*Abandoned solution.*

Subject 14, Circuit Three

Time in = 1532 Time out = 1545 Elapsed time = 13 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "Dim circuit does not work at all."

Studies the schematic.

Hi-lites the affected part of the system on the schematic.

Checks voltage across R1.

Shows system voltage.

Checks resistance of R1.

Shows infinity.

Says, "Replace R1. It is open."

*That is the correct solution.*

Subject 14, Circuit Four

Time in = 1545 Time out = 1550 Elapsed time = five minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "Taxi does not come on."

studies the schematic and Hi-lites the affected part of the schematic.

Operates the system and holds hand against relay two.

Checks voltage at A2 on relay two. Finds voltage.

Checks voltage at A1 on relay two. Finds voltage.

Checks voltage across R3. Does not find voltage.

Says, "It is not open."

Checks voltage at L34B14 and T1 to ground. Does not find voltage.

Isolates L34A14 and checks resistance.

Says, "infinity."

Says, "Replace that wire."

*That is the correct solution.*

Subject 15, Circuit One

Time in = 1530 Time out = 1540 Elapsed time = ten minutes



Subject performed the following actions and articulated the following comments:

Operated the system.

Says, "Lights will work, but motor will not work."

Looks at schematic.

Said the path was through wire L41B20 through the motor to ground.

Disconnected the plug at motor.

Checks voltage at L41B20 and Pin A.

Shows voltage.

reconnects cannon plug.

Studies diagram.

Disconnects plug at unit again.

checks continuity at Pins A to B.

Shows infinity.

Says, "Replace motor."

Subject 15, Circuit Two

Time in = 1541 Time out = 1557 Elapsed time = 16 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "High doesn't work. Low only."

Hi-lites the path from bus (M10A14) to motor through the high speed side.

Removes plug at motor.

Places the switch in high speed position.

Checks voltage A2 at relay four. Shows system.

Checks voltage A3 at relay four. Shows system.

checks voltage X1 at relay four. Shows 0 volts.

Checks Voltage M10C14 at motor. Shows system.

Says everything to motor as should be.

Checks Motor ground. Shows continuity.

Rechecks same.

Reconnects ground.

Says motor has added resistance.

Says, "Replace the motor."

*That is not the correct solution.*

checks voltage X1 to X2 on relay three with switch in high position.

Shows voltage.

Checks voltage X1 to X2 on relay four with switch in high position. Shows system.

*Abandons solution.*

Subject 15, Circuit Three

Time in = 1558 Time out = 1602 Elapsed time = four minutes

Subject performed the following actions and articulated the following comments:

Operated the system.

Says, "No dim setting."

Studies the schematic.

Traces the path from bus through the dim circuit to a point on T1.

Removes L4D20 at R1 and checks voltage.

Says, "Ok."

Removes L4C20 at R1 and checks voltage. Shows 0 volts.

Checks continuity of R1. Shows infinity.

Says, "It is open. Replace it."

*That is the correct solution.*

Subject 15, Circuit Four

Time in = 1603 Time out = 1608 Elapsed time = five minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "No taxi light."

Studies the schematic.

Traces the taxi circuit on the schematic from bus to ground.

Checks voltage at one end of L34B14 to ground.

Shows 0 volts.

Says, "Problem is beyond this point."

checks voltage A1 on relay two to ground. Shows system.

Says L34A14 must be open because system at A1 on R2, but 0 volts at L34B14.

Says, "Replace wire L34B14."

*That is the correct solution.*

Subject 16, Circuit One

Time in = 0852 Time out = 0904 Elapsed time = 14 minutes

Subject performed the following actions and articulated the following comments:

Operated the system.

Studies the schematic.

Removes cannon plug at unit.

Started to use voltmeter as ammeter.

Has difficulty understanding how to connect meter to measure ohms across motor.

Finally checks ohms across motor between Pins A and B and says, "No continuity."

Rechecks continuity this time between Pins A and C and says, "No continuity."

Says, "Replace the motor."

*That is the correct solution.*

Subject 16, Circuit Two

Time in = 0904 Time out = 0955 Elapsed time = 19 minutes

(32 minute break)

Subject performed the following actions and articulated the following comments:

Operates the system.

Studies the schematic.

Operates the system while listening to sounds the relays make.

Studies the schematic.

Says, "The motor is fine in the low mode, but stays in the low mode. Won't go in the high mode."

Traces the paths on the schematic with a hi-liter through the coils in relay three and relay four.

Traces the circuit from the motor to the bus in low speed position and again in the high speed position.

*Asked to move on to the next problem but wanted to return to this problem later. Time is 0914.*

Returned to the problem at 0946

checks continuity of M12A14.

Checks continuity of R2.

Checks continuity of M13B14.

Checks continuity of M13A14.

checks continuity of M12B14.

Checks continuity of M12A14.

Operated system while feeling of relays three and four.

*Abandoned solution.*

Subject 16, Circuit Three

Time in = 0915 Time out = 0928 Elapsed time = 13 minutes

Subject performed the following actions and articulated the following comments:

Operated the system.

Says, "Works in bright, does not work in dim."

Traces the dim path on the schematic.

Operates the system.'

Says he knows that T1 has power (his words) because lights works in bright.

Opens control panel.

Isolates wire L4E20 (I think).

Checks continuity of wire L4E20.

Says to replace the wire.

*Not the correct solution.*

*Researchers notes: Subject did not have wire believed to be testing.*

Rechecks wire again, and again does not have wire believed to be testing.

Rechecks wire, finally getting correct wire. Says, "Ok."

Reconnects wire.

Isolates wire L4D20 and checks continuity. Says, "Ok."

Checks continuity of R1 and says, "infinity."

Says, "Replace resistor."

*That is the correct solution.*

Subject 16, Circuit Four

Time in = 0930 Time out = 0945 Elapsed time = 15 minutes

Subject performed the following actions and articulated the following comments:

Operates the system.

Says, "No taxi light."

Traces the schematic with hi-liter.

Opens control panel.

Isolates L22A20 and checks ohms.

Says, "Replace wire L22A20."

*Incorrect solution.*

Subjects checks wire numbers and discovers had used wrong wires to check continuity.

Finds correct wire ends and checks continuity.

Says, "Ok."

Reconnects wires.

Operates system while feeling relay two.

Operates system again while feeling each relay in secession.

Isolates L34A14 and checks continuity.

Says, "No ohms. Might be it."

Says, "Replace L34A14."

*That is the correct solution.*

Subject 17, Circuit One

Time in = 1522    Time out = 1530    Elapsed time = eight minutes

The subject performed the following actions and articulated the following comments:

Operated the system.

Says, "Lights work, but the motor does not rotate."

Studies schematic.

Unscrews plug to motor.

checks voltage at L41B20 and pin A. Shows voltage.

Checks voltage across motor with motor unhooked.

Shows 0 voltage.

Says, "Motor is open. Replace it."

*That is the correct solution.*

Subject 17, Circuit Two

Time in = 1530    Time out = 1556    Time elapsed = 26 minutes

The subject performed the following actions and articulated the following comments:

Operates the system.

Says, "Same speed in high or low position."

With switch in low speed position;

Checks voltage across X1 and X2 (relay three),

Checks voltage X1 to ground,  
Checks voltage X1 to ground with switch in high position,  
Checks voltage X2 to ground (relay three),  
Checks voltage M12A14 at T1 to ground,  
Checks voltage across Resistor two,  
Checks voltage M13B14 at R1 to ground,  
Checks voltage L34A14 (which end?) to ground,  
Checks voltage M12A14 (which end?) to ground,  
Takes two more voltage readings.

*Abandons solution.*

Subject 17, Circuit Three

Time in = 1558 Time out = 1613 Elapsed time = 15 minutes

The subject performed the following actions and articulated the following comments:

Operates the system.

Says, "No light in the dim position. Ok elsewhere."

Opens control panel.

Checks voltage across two ends of L4E20. No volts.

Checks voltage L4D20 and R1. Says, "Ok."

Checks voltage L4C20 and R1. Says, "No voltage."

Checks voltage across R1. Says, "Shows system voltage."

Checks voltage across L4C20. Says, "Shows 0 volts."

Checks voltage L4B20 at T1.

Rechecks last measurement.

Says, "L4B20 is open."

*Incorrect solution*

*Abandons solution*



Subject 17, Circuit Four

Time in = 1615 Time out = 1615 Elapsed time = 0 minutes

The subject performed the following actions and articulated the following comments:

Operated system.

Says, "I don't know what I am doing."

*Abandons solution*

Subject 18, Circuit One

Time in = 1528 Time out = 1535 Elapsed time = seven minutes

The subject performed the following actions and articulated the following comments:

Operated system.

Says, "It ain't rotating."

Studied schematic.

Wrote problem in margins of schematic.

Said he was going to check voltage at T1 and wire L41B20.

Hunted for wire on board. Found it. Said there was voltage.

Said he was going to check voltage at wire L41B20 and Pin A at motor. Used pin out device. Checked voltage. Looked at schematic. Said he found voltage.

Said he was going to check continuity of motor.

With cannon plug unhooked checked continuity of motor by measuring from Pin A of unit to sheet metal of board.

Said he found infinity. "Motor it is open."

*That is the correct solution.*

Subject 18, Circuit Two

Time in = 1536 Time out = 1556 Elapsed time = 20 minutes

The subject performed the following actions and articulated the following comments:

Operated system.

Studies the schematic.

Says, "Runs at low speed in high speed position. Runs ok in low speed."

Says, "R2 must be the control in the low speed."

Studies the schematic.

Uses a Hi-liter to trace part of the schematic.

Says, "There is a resistor somewhere getting into the High side."

Says, "If the switch between A3 and A2 in relay four stayed open all the time the motor would run slow in high position."

Removes wires M13A14 at A1 on relay three.

Checks continuity of wire. Says, "Ok."

Reconnects wire.

Checks voltage at switch.

Checks voltage A3 on relay four. Shows system.

Checks voltage A2 on relay four. Shows voltage.

Isolates M12A14 and checks ohms. Says, "Ok."

Checks voltage A3 at relay four and A2 at relay four again.

Scratches nose.

checks ohms A1 on relay four to ground.

Checks voltage A1 on relay four. Shows voltage.

*Abandons solution.*

Subject 18, Circuit Three

Time in = 1602    Time out = 1625    Elapsed time = 23 minutes

The subject performed the following actions and articulated the following comments:

Operates system.

Says, "No lights in dim setting."

Studies schematic.

Opens control panel.

Checks ohms L4A20. Says, "OK."

checks ohms L4E20. Says, "Ok."

Studies schematic.

Closes panel.

Opens panel.

Checks ohms at switch and L4B20 through L4C20 at R1. Says, "Shows Ok."

Says, "R1 is open or the switch is open in dim position."

Checked voltage at L4E20 and switch.

*Researchers notes: checked wrong wire.*

Says, "No voltage."

Says, "Replace the switch."

*Incorrect solution.*

*Abandons solution.*

Subject 18, Circuit Four

Time in = 1626    Time out = 1627    Elapsed time = one minute

The subject performed the following actions and articulated the following comments:

Operated system.

Studied the schematic.

Says, "Don't know what I am doing."

*Abandons solution.*

Subject 19, Circuit One

Time in = 1515 Time out = 1519 Elapsed time = four minutes

The subject performed the following actions and articulated the following comments:

Operated system.

Says, "The motor is not working."

Says, "problem in T1 through L41B20 through motor to ground."

Removes the cannon plug at motor.

Checks voltage at pin A on wire L41B20 to ground.

Says, "Got voltage."

Checks continuity Pin A to Pin C on unit.

Showed infinity.

Says, "Replace motor."

*That is the correct solution.*

Subject 19, Circuit Two

Time in = 1520 Time out = 1524 Elapsed time = four minutes

The subject performed the following actions and articulated the following comments:

Operated system.

Studied schematic.

Says, "Operates in low all the time."

Studies the schematic.

Says, "Somewhere in relay four there is a problem."

Removes (unknown) wires from relay four.

Checks continuity between A3 and A2 on relay four.

Shows infinity.

Says, "There is an open in relay four, replace it."

*That is the correct solution.*

Subject 19, Circuit Three

Time in = 1525 Time out = 1530 Elapsed time = five minutes

Operated system.

Looks at schematic.

Says, "Won't work in dim. Ok in bright. Problem in L4E20 through R1 through L4B20."

Checks voltage L4C20 and R1 to ground. Shows zero volts.

Checks voltage T1 to ground. Shows system.

Says R1 is open.

Checks continuity of R1.

Shows infinity.

Says, "Replace R1."

*That is the correct solution.*

Subject 19, Circuit Four

Time in = 1530 Time out = 1536 Elapsed time = six minutes

The subject performed the following actions and articulated the following comments:

Operates system.

Says, "Taxi lights don't work. Landing Ok."

Studies schematic.

Checked voltage at A2 on relay two to ground.

shows zero volts.

Says he should have got system voltage.

Checks voltage A2 to ground on relay one. Shows no voltage.

Operates the system.

Studies the schematic.

Rechecked last measurement.

Says, "Now it shows system."

Rechecks voltage at A2 on relay two to ground. Shows system.

Checks voltage A1 to ground on relay two. Has voltage he says.

checks voltage at T1 and end of wire L34A14.

shows zero voltage.

Says, "L34A14 is open. Replace it."

*That is the correct solution.*

Subject 20, Circuit One

Time in = 0842    Time out = 0845    Elapsed time = three minutes

The subject performed the following actions and articulated the following comments:

Operates the system.

Says, "The motor does turn, but the light are ok."

Disconnects plug at unit.

Checks voltage without switch on.

Repeats measurement with switch on.

Says, "Shows voltage. Wire is good."

Says, "Replace the motor."

*That is the correct solution.*

Subject 20, Circuit Two

Time in = 0846 Time out = 0856 Elapsed time = ten minutes

The subject performed the following actions and articulated the following comments:

Operates system.

Says, "Motor runs slow in high speed position."

Removes plug at motor.

Reconnects plug at motor.

Looks at schematic.

Operates system in high speed position.

Checks voltage at A1 on relay three.

Operates system in high speed position again.

Checks voltage at X1 on relay three.

Studies schematic.

Says, "Replace switch."

*That is not the correct solution.*

*Abandoned solution.*

Subject 20, Circuit Three

Time in = 0857 Time out = 0907 Elapsed time = ten minutes

The subject performed the following actions and articulated the following comments:

Operates system.

Says, "Brights ok, dim doesn't work."

Checks voltage L4E20 and T1.

Checks voltage L4B20 at T1.

Checks voltage L4C20 at R1

Says, "Wire L4C20 is open."

Did not say to replace it.

Checks voltage across R1.

Puts switch in bright position.

checks voltage across R1.

Studies schematic.

Says, "It can't be the resistor because it works in the bright position."

Checks voltage L4C20 at T1.

Checks voltage L4D20 at T1.

Checks voltage L4C20 at T1.

Says, "Replace R1."

*That is the correct solution.*

Subject 20, Circuit Four

Time in = 0908 Time out = 0926 Elapsed time = 18 minutes

The subject performed the following actions and articulated the following comments:

Operates system.

Says, "No taxi lights."

Checks voltage at A1 on relay three.

Checks voltage at L34B14 on resistor three.

Checks voltage L33B14 at resistor three.

Checks voltage A1 at relay one.

Says, "Wire L34B14 is open, replace it."

*Incorrect solution.*

Repeats last measurement.

Checks voltage A2 at relay two.

Checks voltage A2 at relay one.



Says, "Replace relay one."

*Incorrect solution.*

*Abandons solution.*

Subject 21, Circuit One

Time in = 0915 Time out = 0919 Elapsed time = four minutes

The subject performed the following actions and articulated the following comments:

Operates system.

Says, "Does not rotate."

Studies the schematic.

Turns master switch off.

Isolates wire L41B20.

Checks ohms across it.

Says to replace motor.

*That is the correct solution.*

Subject 21, Circuit Two

Time in = 0919 Time out = 0924 Elapsed time = five minutes

The subject performed the following actions and articulated the following comments:

Operates system.

Says, "Runs ok in low, but continues to run in low speed when in high position."

Studies the schematic and traces part of it with hi-liter.

Says, "Replace relay four."

*That is the correct solution.*

Subject 21, Circuit Three

Time in = 0924 Time out = 0926 Elapsed time = two minutes

The subject performed the following actions and articulated the following comments:

Operates the system.

Says, "Nav lights do not come on in the dim position."

Studies the schematic.

Checks ohms of R1.

Says, "it is open. Replace it."

*That is the correct solution.*

Subject 21, Circuit Four

Time in = 0926 Time 0935 Elapsed time = nine minutes

The subject performed the following actions and articulated the following comments:

Operates the system.

Says, "No taxi lights, but landing light are ok."

Studies schematic.

Disconnects wires to R3.

Checks ohms of R3.

Says it is ok.

Studies the schematic.

Traces the circuit with a hi-liter.

Says, "replace relay two."

*That is not the correct solution.*

Checks voltage A1 at relay two.

Checks voltage X1 at relay two.

Checks voltage X2 at relay two.

Checks voltage L34A14 at T1.

Checks voltage L34A14 at relay.

Says, "replace the wire."

*That is the correct solution.*

Subject 22, Circuit One

Time in = 1529 Time out = 1536 Elapsed time = seven minutes

The subject performed the following actions and articulated the following comments:

Operated the system.

Studied the schematic.

Measured the resistance pin A of beacon unit to sheet metal of board.

Thought about what he was doing and rechecked resistance Pin A to Pin C of beacon unit.

Said he measured low resistance.

Checked continuity of wire L41B20 and said it was ok.

Rechecked Pin A to Pin C at beacon unit and said he found infinity this time.

Says, "Replace the motor."

*That is the correct solution.*

Subject 22, Circuit Two

Time in = 1537 Time out = 1547 Elapsed time = ten minutes

The subject performed the following actions and articulated the following comments:

Operated the system.

Says, "It is running at high speed in both positions."

Studied the schematic and hi-lited part of it.

Checked voltage across connections X1 and X2 in relay four.

Said he had a 22 one/two volts there which was ok.

*Instructors note: switch was in low position.*

Checks voltage across A2 and A3 in relay four.

22 one/two volts.

Studied the schematic.

Says, "replace R4."

*That is the correct solution.* Subject 22, Circuit Three

Time in = 1548 Time out = 1600 Elapsed time = 12 minutes

The subject performed the following actions and articulated the following comments:

Studied the schematic.

Operated system.

Says, "Not working in dim, no matter steady or flash."

Hi-lited part of the schematic.

Checks continuity of wire L4E20 from switch to Terminal strip. Showed ok.

Checks voltage across R1.

Shows system.

Says R1 is open and to replace it.

*That is the correct solution.*

Subject 22, Circuit Four

Time in = 1601 Time out = 1610 Elapsed time = nine minutes

The subject performed the following actions and articulated the following comments:

Operated system.

Says, "Will not run in taxi position."

Studied schematic.

*Researchers notes: correctly identifies critical path of influence.*

Checks voltage across R3. Says it is ok because no voltage drop.

checks voltage at T1 where L34B14 connects.

Shows no voltage.

Checks voltage A1 and R2. Shows voltage.

Checks continuity of wire L34A14.

Says, "Replace that wire."

*That is the correct solution.*

Subject 23, Circuit One

Time in = 1512 Time out = 1523 Elapsed time = 11 minutes

The subject performed the following actions and articulated the following comments:

Operates system.

Says, "Motor doesn't rotate, but lights are ok."

Studies the diagram.

Says, "I am going to check wire L41B20."

Hunts for the wire, finds it.

Unscrews plug at motor.

Puts voltmeter across wire L41B20 with one end connected to T1 and other end connect to Pin A at cannon plug.

Disconnects L41B20 from T1 and checks ohms.

Went from ground and one end of wire.

Shows infinity.

Screws plug back into motor unit.

Checks ohms loose end of wire L41B20 and to frame.

shows infinity.

Says, "Replace the wire."

*incorrect solution.*

Says, "Ok, then replace the motor."

*That is the correct solution.*

Subject 23, Circuit Two

Time in = 1524 Time out = 1530 Elapsed time = six minutes

The subject performed the following actions and articulated the following comments:

Operated the system.

Says, "Motor runs in low speed all the time."

Studies the schematic.

Hi-lites the low speed side of the schematic.

Hi-lites the high speed side of the schematic.

Studies the schematic.

Talks to herself.

Says, "Replace the switch."

*Incorrect solution*

Took a couple of voltage readings across terminals of Relay three and relay four.

Turned system on in the high speed position.

Repeated last voltage measurements.

Says, "Replace relay four."

*That is the correct solution.*

Subject 23, Circuit Three

Time in = 1530 Time out = 1538 Elapsed time = eight minutes

The subject performed the following actions and articulated the following comments:

Operated the system.

Says, "Works in the bright position, but will not work in the dim position."

Studies schematic.

Traces and hi-lite from switch through the dim circuit on the schematic.

Checks voltage at switch and L4E20.

First hunts for and finds L4E20 at T1, then opens panel and checks at switch.

Shows system voltage according to subject.

Says, "Replace the wire L4E20."

*Incorrect solution.*

Checks voltage at L4D20 and R1 to ground.

Checks voltage across R1 and says it show system.

Says, "Replace R1."

*That is the correct solution.*

Subject 23, Circuit Four

Time in = 1539 Time out = 1550 Elapsed time = 11 minutes

The subject performed the following actions and articulated the following comments:

Operates the system.

Says, "Taxi light does not work."

Studies the system.

Traces the taxi light circuit on the schematic.

Checks voltage X1 and X2 on relay two.

Checks voltage X2 relay two to ground.

Checks voltage X1 relay two to ground.

Repeats measurement.

Checks voltage at switch and L22A20 to ground.

Checks voltage A1 to A2 on relay two. Shows system.

Says, "Replace the relay."

*incorrect solution.*

Checks ohms of wire L22A20 after isolating it.

Places meter to ground and one end of wire.

Places ohmmeter across wire. Says, "Ok."

Says, "Replace switch."

*Incorrect solution.*

Checks voltage X2 to ground on relay two.

Checks voltage X1 to ground on relay two.

Checks voltage X1 to L22A20 at switch.

Checks voltage across R3.

Says, "Replace R3."

*Incorrect solution*

Checks voltage across L33B14

Checks voltage across L34B14

Checks voltage across L33A14

Checks voltage across L32A14

Checks voltage across L34A14

Says, "Replace L34A14."

*That is the correct solution.*

Subject 24, Circuit One

Time in = 0945 Time out = 0954 Elapsed time = nine minutes



The subject performed the following actions and articulated the following comments:

Operated the system.

Says, "The motor is not rotating."

Looks at schematic.

Checks voltage at L41B20 and T1.

Shows zero voltage.

Checks voltage at L41B20 and Pin A on cannon plug.

Shows zero voltage.

Switch for rotating beacon was off.

Checks between Pin A and Pin C (continuity) of beacon unit.

Says, "Open motor, replace it."

*That is the correct solution.*

Subject 24, Circuit Two

Time in = 0955 Time out = 1021 Elapsed time = 26 minutes

The subject performed the following actions and articulated the following comments:

Operated the system.

Says, "Low works. High is not working properly."

Looks at schematic.

Checks voltage on M11B20 and the switch to ground.

finds system.

Checks continuity between X1 and X2 on relay three.

Finds 98 ohms.

Checks voltage at X2 on relay three.

Zero voltage.

Checks voltage at X2 again.

Same reading as before.

Says, "Replace relay three."

*incorrect solution*

Time is 1006

Studies the schematic a long time.

Checks continuity between A2 and A3 on relay four.

Says, "Replace relay four."

*That is the correct solution.*

Subject 24, Circuit Three

Time in = 1022    Time out = 1027    Elapsed time = five minutes

The subject performed the following actions and articulated the following comments:

Operates system.

Says, "Dim is not working."

Studies the schematic.

Checks voltage on wire L4E20 at T1.

System voltage.

checks voltage at R1 and L4C20 to ground.

0 voltage.

Checks voltage at L4D20 at Resistor one.

System voltage

Says, "Replace resistor one."

*That is the correct solution.*

Subject 24, Circuit Four

Time in = 1028    Time out = 1034    Elapsed time = six minutes

The subject performed the following actions and articulated the following comments:

Operates system.

Says, "Taxi lights do not work."

Traces on the schematic with a Hi-liter.

Checks voltage at L34A14 and T1.

Finds voltage.

Checks voltage at A1 on relay two.

Finds system voltage.

Says, "L34A14 is open, replace it."

*That is the correct solution.*

Subject 25, Circuit one

Time in = 1649 Time out = 1654 Elapsed time = six minutes

The subject performed the following actions and articulated the following comments:

Operates the system.

Says, "Rotating beacon is not rotating."

Studies the schematic.

Checks voltage at L41B20 at Pin A on cannon plug.

finds 22.nine volts.

Says, "Ok."

Checks voltage Pin C to ground.

Says, "0 volts. Ok."

Says, "Replace wire from Pin C to Ground."

*That is not the correct solution.*

Says, "Ok then, replace the motor."

*That is the correct solution.*

Subject 25, Circuit Two

Time in = 1650 Time out = 1702 Elapsed time = 12 minutes

The subject performed the following actions and articulated the following comments:

Operates the system.

Says, "Low ok. High runs in low all the time."

Traces the schematic with Hi-liter.

Checks Point A2 on relay four for voltage.

Finds seven.three volts.

Says, "Replace relay four."

*That is the correct solution.*

Subject 25, Circuit Three

Time in = 1703 Time out = 1708 Elapsed time = five minutes

The subject performed the following actions and articulated the following comments:

Operates the system.

Says, "Dim is not working."

Looks at schematic.

Checks L4E20 at T1 for voltage.

Finds system.

Checks voltage at L4D20 and R1.

Finds system.

Checks voltage at L4C20 and unknown point.

Says, "Got zero volts."

Says, "Replace R1."

*That is the correct solution.*

Subject 25, Circuit Four

Time in = 1708 Time out = 1713 Elapsed time = five minutes

The subject performed the following actions and articulated the following comments:

Operates the system.

Says, "The taxi lights do not work."

Studies the schematic.

Checks voltage L34B14 at Resistor three.

Zero voltage.

Checks voltage L33B14 at Resistor three.

Zero voltage.

Checks voltage A1 on relay two.

System voltage.

Says, "Wire L34A14 is open."

*That is the correct solution.*

Subject 26, Circuit One

Time in = 1606 Time out = 1613 Elapsed time = seven minutes

The subject performed the following actions and articulated the following comments:

Operates the system.

Says, "It will not rotate."

Looks at the schematic.

Checks continuity of motor from pins A to Pin C of unit.

Says, "No continuity. Replace the motor."

*That is the correct solution.*

Subject 26, Circuit Two

Time in = 1614 Time out = 1637 Elapsed time = 23 minutes

The subject performed the following actions and articulated the following comments:

Operates the system.

Says, "Low works ok. High works in low speed setting."

Studies the schematic.

Checks continuity of R2.

Says, "Ok."

Checks voltage across R2 with switch in high speed position.

Finds 13.eight volts.

Checks voltage across R2 with switch in low speed position.

Finds 13.eight volts.

Checks continuity between A2 and A1 of relay four. Finds nothing.

Checks continuity between A2 and A3 of relay four. Finds nothing.

Says, "Replace relay four."

*That is the correct solution.*

Subject 26, Circuit Three

Time in = 1639 Time out = 1655 Elapsed time = 16 minutes

The subject performed the following actions and articulated the following comments:

Operates the system.

Says, "The dim is not working."

Looks at the schematic.

Checks voltage L4B20 at T1.

Zero voltage.

Checks continuity switch to T1 for wire L4E20.

Says, "Good."

Checks continuity across Resistor one.

Says, "Bad resistor, replace it."

*That is the correct solution.*

Subject 26, Circuit Four

Time in = 1656 Time out = 1707 Elapsed time = 11 minutes

The subject performed the following actions and articulated the following comments:

Operates the system.

Says, "The taxi lights do not work."

Checks voltage at L33A14 and T1 to ground.

Says, "ok."

Checks voltage L34B14 at T1 to ground.

Says, "System voltage."

Checks voltage L34A14 at T1 to ground.

Says, "zero volts."

Says, "L34A14 is open."

Says, "Replace it."

*That is the correct solution.*

Subject 27, Circuit One

Time in = 1016 Time out = 1023 Elapsed time = seven minutes

The subject performed the following actions and articulated the following comments:

Operates the system.

Says, "The motor is not turning."

Looks at schematic.

Checks L41B20 for continuity.

Says, "Ok."

Looks at schematic.

Says, "Replace the motor."

*That is the correct solution.*

Subject 27, Circuit Two

Time in = 1019 Time out = 1038 Elapsed time = 19 minutes

The subject performed the following actions and articulated the following comments:

Operates the system.

Says, "Runs in low, ok. High running in low speed."

Looks at schematic.

Operates the system.

Says, "I don't know."

*Abandons solution.*

Subject 27, Circuit Three

Time in = 1039 Time out = 1047 Elapsed time = eight minutes

The subject performed the following actions and articulated the following comments:

Operates the system.

Says, "The dim is not working."

Looks at schematic.

Checks continuity of wire L4A20.

Says, "Ok."

Checks continuity between dim switch and Resistor one. Wires L4E20 and L4D20.



Says, "Ok."

Checks for open in Resistor one.

Says, "Replace resistor one."

*That is the correct solution.*

Subject 27, Circuit Three

Time in = 1039 Time out = 1047 Elapsed time = eight minutes

The subject performed the following actions and articulated the following comments:

Operates the system.

Says, "Dim is not working."

Looks at schematic.

Checks continuity of L4A20.

Says, "Ok."

Checks continuity between Dim switch and R1 (wires L4E20 and L4D20).

Says, "Ok."

Checks continuity of Resistor one.

Says, "Replace that resistor."

*That is the correct solution.*

Subject 27, Circuit Four

Time in = 1048 Time out = 1056 Elapsed time = eight minutes

The subject performed the following actions and articulated the following comments:

Operates the system.

Says, "Landing lights are ok. Taxi are not working."

Looks at schematic.

Checks continuity of L31A14.

Says, "Ok."

Checks continuity of L34A14.

Says, "No continuity."

Checks continuity of L34B14.

Says, "Replace the other wire. Wire L34A14."

*That is the correct solution.*

Subject 28, Circuit One

Time in = 1716 Time out = 1722 Elapsed time = six minutes

The subject performed the following actions and articulated the following comments:

Operates the system.

Says, "Motor is not rotating."

Looks at schematic.

Checks voltage at L41B20 and pin A of cannon plug.

Says, "got system."

Says, "must be an open in the motor, replace it."

*That is the correct solution.*

Subject 28, Circuit Two

Time in = 1723 Time out = 1748 Elapsed time = 25 minutes

The subject performed the following actions and articulated the following comments:

Operates the system.

Says, "High is running on low speed setting. The low is ok."

Looks at schematic.

Checks voltage at M11B20 and X1 on relay three.

Finds system.

Checks voltage at M41C20 at X1 on relay four.

Finds system.

Operates system again.

Checks voltage at A2 on relay four.

Finds system.

Checks voltage between A2 and A3 on relay four.

Says, "Zero volts."

Says, "Replace relay four."

*That is the correct solution.*

Subject 28, Circuit Three

Time in = 1750 Time out = 1802 Elapsed time = 12 minutes

The subject performed the following actions and articulated the following comments:

Operates the system.

Says, "Dim is not working."

Looks at schematic.

Checks voltage at L4D20 and T1.

finds system.

Checks voltage at L4D20 and R1.

Finds system.

Checks continuity of R1.

Says, "Resistor is open, replace it."

*That is the correct solution.*

Subject 28, Circuit Four

Time in = 1805 Time out = 1820 Elapsed time = 15 minutes

The subject performed the following actions and articulated the following comments:

Operates the system.

Says, "Taxi is not working."

Looks at schematic.

Checks voltage at L31A14 and A2 on relay one.

Finds system.

Checks voltage at L31A14 and A2 on relay two.

Finds 0 volts.

Checks voltage between A2 and A1 on relay two.

Says, "ok."

Says, "replace wire L34A14."

*That is the correct solution.*

Subject 29, Circuit one

Time in = 1615   Time out = 1622   Elapsed time = seven minutes

The subject performed the following actions and articulated the following comments:

Operates the system.

Looks at the schematic.

Says, "the motor is not turning."

Checks voltage at L41B20 and T1.

Checks voltage at L41B20 at Pin A on cannon plug.

Checks continuity between pin A and Pin C on unit.

Says, "Motor is bad. Replace it."

*That is the correct solution.*

Subject 29, Circuit Two

Time in = 1623 Time out = 1640 Elapsed time = 17 minutes

The subject performed the following actions and articulated the following comments:

Operates the system.

Looks at the schematic.

Says, "Low is ok. High runs like it is in low all the time."

Checks continuity between X1 and X2 on relay four.

Says, "ok."

Checks voltage between A2 and A3 on relay four.

Says, "Relay four is open. Replace it."

*That is the correct solution.*

Subject 29, Circuit Three

Time in = 1642 Time out = 1654 Elapsed time = 12 minutes

The subject performed the following actions and articulated the following comments:

Operates the system

Says, "Lights not working in dim."

Looks at schematic.

Checks voltage at L4E20 and T1 to ground.

Finds system.

Checks voltage at L4D20 at R1 to ground.

Finds system.

Checks voltage L4C20 and T1 to ground.

Finds 0 volts.

Checks continuity of R1.

Says, "Open."

*That is the correct solution.*

Subject 29, Circuit Four

Time in = 1655 Time out = 1702 Elapsed time = seven minutes

The subject performed the following actions and articulated the following comments:

Operates the system.

Says, "Taxi light position is not working."

Looks at the schematic.

Checks voltage at L34A14 and A2 on relay two.

Finds system.

Checks voltage A2 to A1 on relay two.

Says, "Got system."

Checks voltage L34A14 at A1.

Finds system.

Checks voltage L34A14 at T1.

Finds zero volts.

Says, "Wire L34A14 is open. Replace it."

*That is the correct solution.*

Subject 30, Circuit one

Time in = 1210 Time out = 1220 Elapsed time = ten minutes

Subject made two measurements with voltmeter.

Subject made two measurements with ohmmeter.

Subject correctly diagnosed the fault the first time.

Circuit two

Time in = 1221 Time out = 1241 Elapsed time = 20 minutes

Subject made four measurements with voltmeter.

Subject incorrectly diagnosed the circuit with first solution.

Subject correctly diagnosed the circuit with second solution.

Circuit three

Time in = 1245 Time out = 1255 Elapsed time ten minutes

Subject made four measurements with voltmeter.

Subject correctly diagnosed the circuit with first solution.

Circuit four

Time in = 1256 Time out = 1300 Elapsed time = four minutes

Subject made two measurements with voltmeter.

Subject correctly diagnosed the circuit with first solution.